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Open File Report 6094

Data for the Comparative Resource Evaluation of Selected Shale Units, Southern Ontario

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Data for the Comparative Resource Evaluation of Selected Shale Units, Southern Ontario

by

D.K. Armstrong and P. Sergerie

2002

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Contents

Abstract xi

Introduction 1

Methodology 3

Previous Work 7

Geological Overview 8
- Paleozoic Stratigraphy 8
- Drift Cover 10

Geochemical Results 11
- Bed Samples 11
  - Queenston Formation 11
  - Georgian Bay Formation 12
  - Blue Mountain Formation 14
  - Lower Silurian Units 16
- Composite Samples 16
- Chlorine and Fluorine data 17

Results of Field Work and Drilling Program 20
- Blue Mountain Formation 20
- Georgian Bay Formation 26
- Queenston Formation 40

Ceramic Testing 49
- Ceramic Testing Methodology 49
- Ceramic Testing Results 51

Summary and Conclusions 54

Recommendations 57

References 58

Appendix 1. Mapping station information 64

Appendix 2. Field composite sample information 70

Appendix 3. Field bed sample information 74

Appendix 4. Major and minor element data for field composite samples 83

Appendix 5. Major and minor element data for field bed samples 86

Appendix 6. 2001 drill hole logs and geochemical data 93

Appendix 7. Chlorine and fluorine geochemical data for bed and composite samples from 2000 125

Appendix 8. Ceramic testing results 127

Metric Conversion Table 160

FIGURES

1. Paleozoic bedrock geology map of the study area, showing locations of 2001 and 2000 mapping stations, drill holes (from OGS programs in 1989, 2000, 2001 and others used in this study), thin drift areas over the Queenston, Georgian Bay, and Blue Mountain formations and their equivalents in eastern Ontario, municipality boundaries and the Niagara Escarpment Commission (NEC) Plan Area: a) south-central Ontario study area; b) eastern Ontario study area ..... back pocket
2. Generalized bedrock geology map of south-central Ontario, highlighting the distribution of the Queenston, Georgian Bay and Blue Mountain formations, areas of thin drift over these units, and locations of the 2001 OGS drill holes 4
3. Generalized bedrock geology map of eastern Ontario, highlighting the distribution of the Queenston, Carlsbad and Billings formations, areas of thin drift over these units, and the location of OGS drill hole OGS-01-06 5
4. Composite section of 15 Blue Mountain Formation outcrops along Christie Beach Creek (station 01DKA-024), southeast of Meaford 21
5. Plot of selected element oxide contents in bed samples from the Christie Beach Creek section (station 01DKA-024) 23
6. Plot of selected element oxide contents in composite samples from drill hole OGS-01-03 (station 01DKA-032) 24
7. Plot of selected element oxide contents in bed samples from the Southeast Claybanks section (station 01DKA-018) 25
8. Composite section of 37 outcrops along East Meaford (Workman's) Creek (station 01DKA-019) 27
9. Plot of selected element oxide contents in bed samples from the East Meaford Creek section (station 01DKA-019) 29
10. Plot of selected element oxide contents in composite samples from drill hole OGS-01-01 (station 01DKA-030) 30
11. Plot of selected element oxide contents in composite samples from drill hole OGS-01-02 (station 01DKA-031) 31
12. Composite section of the Georgian Bay Formation from 20 outcrops along Sucker Creek (station 01DKA-022), northwest of Meaford 34
13. Plot of selected element oxide contents in bed samples from the Sucker Creek section (station 01DKA-022) 35
14. Plot of selected element oxide contents in composite samples from drill hole OGS-01-04 (station 01DKA-033) 36
15. Plot of selected element oxide contents in composite samples from drill hole OGS-01-05 (station 01DKA-034) 37
16. Plot of selected element oxide contents in bed samples from drill hole OGS-01-06 (station 01DKA-035) 39
17. Composite section and unit descriptions for the Queenston Formation exposed in the Mansfield Ski Hill road cut (station 01DKA-014) 43
18. Plot of selected element oxide contents in bed samples from the Mansfield Ski Hill road cut (station 01DKA-014) 44
19. Plot of selected element oxide contents in composite samples from the Duntroon Quarry core OGS-80-1 (station 01DKA-011) 45
20. Plot of selected element oxide contents in composite samples from the Russell Quarry (station 01DKA-020) 48

TABLES

1. Upper Ordovician and Lower Silurian stratigraphic chart for the Niagara Escarpment area and eastern Ontario 2
2. Locations and preliminary results of 2001 Ontario Geological Survey drilling program 3
3. Summary of selected geochemical results for all 2001 Queenston Formation bed samples from outcrops. 12
4. Summary of selected geochemical results for 2001 Queenston Formation red and green shale bed samples from outcrops 12
5. Summary of selected geochemical results for all 2001 Georgian Bay Formation bed samples from outcrops. 13
6. Selected element content averages for shale and non-shale Georgian Bay Formation bed samples from 3 drill cores (OGS-01-01, OGS-01-02, OGS-01-05). 14
7. Summary of selected geochemical results for all 2001 Blue Mountain Formation bed samples 15
8. Geochemical comparison of northern (Meaford area) and southern (Rouge River area) Blue Mountain Formation shale samples. 15
9. Summary of selected geochemical data for 2000 Lower Silurian shale bed samples. 16
10. Average values of selected elements for composite samples grouped by formation from 2001 OGS drill holes. 17
11. Summary of fluorine content in bed samples of Queenston Formation samples. 18
12. Summary of fluorine data for Queenston Formation composite samples from outcrops, quarries, and OGS drill holes. 18
13. Chlorine and fluorine data from 1989 OGS drill holes 19
14. Geochemistry of formational intervals in OGS drill holes from 2001, 2000 and 1989 drilling programs. 32
15. Average content of selected elements for 2001 Queenston Formation field mapping stations. 40
16. Relationship of ceramic testing samples to source drill holes and composite geochemical samples. 49
17. Summary of ceramic test results and selected geochemical analyses for Group 2 core samples of the Queenston Formation. 52

Abstract

The Upper Ordovician Queenston Formation is the main source of raw shale for the brick industry in Ontario. Competing land use pressures in the area where this unit has historically been extracted are increasingly limiting access to this resource. In 2000, the Ontario Geological Survey initiated a study of the Queenston Formation to better understand its resource potential, both within the area of present extraction, and regionally, along its outcrop belt. In 2001, the study was expanded to include comparative analysis of 2 other Ordovician shale units, the Georgian Bay and Blue Mountain formations.

Resource potential is based, among other things, upon thickness of drift cover and shale mineralogy and geochemistry. Thin drift (<8 m) areas, identified from published sources, were the focus of field and drilling investigations. Mineralogically and geochemically these 3 formations are generally similar, however, there are a few significant exceptions, including the Queenston Formation is more calcareous and contains local concentrations of gypsum; the Blue Mountain Formation and parts of the Georgian Bay Formation contain more sulphur in the form of pyrite; and locally, the Blue Mountain Formation contains higher levels of organic carbon.

The Queenston Formation consists mainly of red silty shale with subordinate interbeds of calcareous siltstone and sandstone and local minor limestone. Gypsum, a deleterious component in brick making, occurs as nodules and fracture-fillings in the middle and lower parts of the Queenston Formation. Carbonate and iron content are main factors governing brick colour in the Queenston Formation. Shales with Fe_2O_3/CO_2 ratios greater than 0.50 yield red coloured bricks; values less than 0.50 yield tan-yellow bricks. Carbonate content increases throughout the whole formation towards the north.

Both the Georgian Bay and Blue Mountain formations contain shale-dominated intervals alternating with intervals of interbedded shale, limestone and sandstone. Limestone and sandstone beds are more abundant and thicker in the Georgian Bay Formation, especially in its upper part. The middle and lower parts of the Georgian Bay Formation, as well as the entire Blue Mountain Formation, contain economically significant shale-dominated intervals.

Drift cover is thickest and most extensive over all 3 formations in the central part of their outcrop belts. In the south, urbanization has virtually covered all thin drift areas over the Georgian Bay and Blue Mountain formations. Access to the high-quality shale resources of the upper Queenston Formation is restricted because this part of the formation lies mostly within the Niagara Escarpment Plan Area. However, significant Queenston Formation shale resources remain in the south, with a number of undeveloped thin drift areas affording access to shales from a wide stratigraphic range within the Queenston Formation. In the north, especially near Meaford, relatively large areas of thin drift occur over all 3 formations, however, only parts of these formations contain suitable shale resources in this region.

Data for the Comparative Resource Evaluation of Selected Shale Units, Southern Ontario

D.K. Armstrong and P. Sergerie
Ontario Geological Survey
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Introduction

In 2000, the Ontario Geological Survey (OGS) initiated a study of the Upper Ordovician Queenston Formation, the main source of shale for Ontario's brick industry. This study was undertaken because in the Toronto–Brampton–Hamilton area of southern Ontario, where this unit has historically been extracted, increasing land use pressure is restricting access to future resources.

In 2000, the Queenston Formation shales were examined in operating quarries, major outcrops, and existing and new drill cores (Armstrong 2000a). Areas of thin drift over the Queenston Formation were specifically targeted for evaluation, both within the area of present extractive activity and along the whole outcrop belt of this formation in southern Ontario. Samples obtained from quarry and natural outcrop exposures, and drill cores were analyzed geochemically. Selected core intervals were subjected to ceramic testing. Data from these analyses were presented in Miscellaneous Releases of Data (MRD) 77 and 92, respectively (Armstrong 2001a, Armstrong and Frederic 2001), and results of the first year of study were presented in OGS Open File Report 6058 (Armstrong 2001b).

In 2001, the scope of this project was expanded to include comparative studies of 2 other Upper Ordovician shale units, the Blue Mountain and Georgian Bay formations. Field work was conducted in the summer of 2001 and a drilling program undertaken during the subsequent fall and winter. This phase of the project also addressed areas underlain by the Queenston Formation that were not covered by the 2000 program (i.e., eastern Ontario). Additionally, this report includes analysis of samples obtained during the 2000 field season from 2 Lower Silurian shale-dominated units, the Cabot Head and Wingfield formations. Geochemical analysis of samples obtained during the field component of the 2001 program are presented in MRD 107 (Armstrong and Sergerie 2002a). Data from the 2001–2002 drilling program are presented in MRD 112 (Armstrong and Sergerie 2002b). A stratigraphic chart illustrating the age and distribution of the Upper Ordovician and Lower Silurian units which are the focus of this report is presented in Table 1.

Table 1: Upper Ordovician and Lower Silurian stratigraphic chart for the Niagara Escarpment area and eastern Ontario (*from* Johnson et al. 1992). Shale-dominated formations are highlighted in bold. Vertical hatch indicates strata not preserved. Note: "Fm" = Formation; "Mb" = Member.

<table>
<tr><th rowspan="2">Age</th><th colspan="4">Geographic Areas</th></tr>
<tr><th>Niagara Peninsula</th><th>Creemore-Collingwood</th><th>Bruce Peninsula</th><th>Eastern Ontario</th></tr>
<tr><td rowspan="6">Lower Silurian</td><td rowspan="3"></td><td rowspan="3"></td><td>St. Edmund Fm</td><td rowspan="6"></td></tr>
<tr><td>Wingfield Fm</td></tr>
<tr><td rowspan="2">Grimsby Fm</td><td>Dyer Bay Fm</td></tr>
<tr><td rowspan="2">Cabot Head Fm</td><td rowspan="2">Cabot Head Fm</td></tr>
<tr><td>Manitoulin Fm</td><td rowspan="2">Manitoulin Fm</td></tr>
<tr><td>Whirlpool Fm</td><td>Whirlpool Fm</td></tr>
<tr><td rowspan="3">Upper Ordovician</td><td>Queenston Fm</td><td>Queenston Fm</td><td>Queenston Fm</td><td>Queenston Fm</td></tr>
<tr><td>Georgian Bay Fm</td><td>Georgian Bay Fm</td><td>Georgian Bay Fm</td><td>Carlsbad Fm</td></tr>
<tr><td>Blue Mountain Fm</td><td>Blue Mountain Fm</td><td>Blue Mountain Fm</td><td>Billings Fm</td></tr>
</table>

Methodology

The second year of the project followed essentially the same methodology as was used in the first year of the study (Armstrong 2001b). Major outcrops of the Blue Mountain and Georgian Bay formations, identified by previous workers (e.g., Liberty 1969; Liberty and Bolton 1971), were re-examined and sampled. Areas of thin drift (less than 8 m) over these units, identified from published reports (e.g., Golders Associates Ltd. and Rowell 1996a) and illustrated on Figures 1a (back pocket) and 2, were used to focus field investigations and to site drill holes. Areas of thin drift over these units in eastern Ontario (Figures 1b (back pocket) and 3) were identified from bedrock resource maps in aggregate resource reports by Rowell (1997a, 1997b), and from data available on the Geological Survey of Canada's "Urban Geology of the National Capital Area" website (Bélanger 2002).

A drill program consisting of 6 drill holes was designed to test these shale units in areas of thin drift, obtain local and regional stratigraphic information. Four holes targeted the Georgian Bay Formation (2 of these were collared in the lowermost Queenston Formation), 1 drill hole was sited in the Blue Mountain Formation, and 1 hole targeted the Queenston and Carlsbad formations in eastern Ontario. The locations of these drill holes are plotted in Figures 1 (back pocket), 2 and 3, and listed in Table 2.

Table 2: Locations and preliminary results of 2001 Ontario Geological Survey drilling program (note: UTM coordinates in NAD 83; all units in metres). Detailed logs of these holes are presented in Appendix 6.

Hole #	General Location	UTM easting	UTM northing	Overburden Thickness	Total Depth Drilled	Bedrock Units (thickness)
OGS-01-01	Tullamore, northeast of Brampton	598950	4850250	1.50	32.00	Georgian Bay (30.50 m)
OGS-01-02	east of Rosemont, west of Alliston	584657	4885765	2.25	37.72	Georgian Bay (35.47 m)
OGS-01-03	Christie Beach Road, east of Meaford	538606	4937283	1.60	44.12	Blue Mountain (42.52 m)
OGS-01-04	southeast of Meaford	536270	4936455	0.00	61.08	Queenston (13.82 m), Georgian Bay (47.26 m)
OGS-01-05	Balaclava, northwest of Meaford	519274	4948872	2.59	61.27	Queenston (2.09 m), Georgian Bay (56.59 m)
OGS-01-06	Russell Quarry, east of Ottawa	470909	5016616	1.50	60.96	Queenston (21.45 m), Carlsbad (38.01 m)

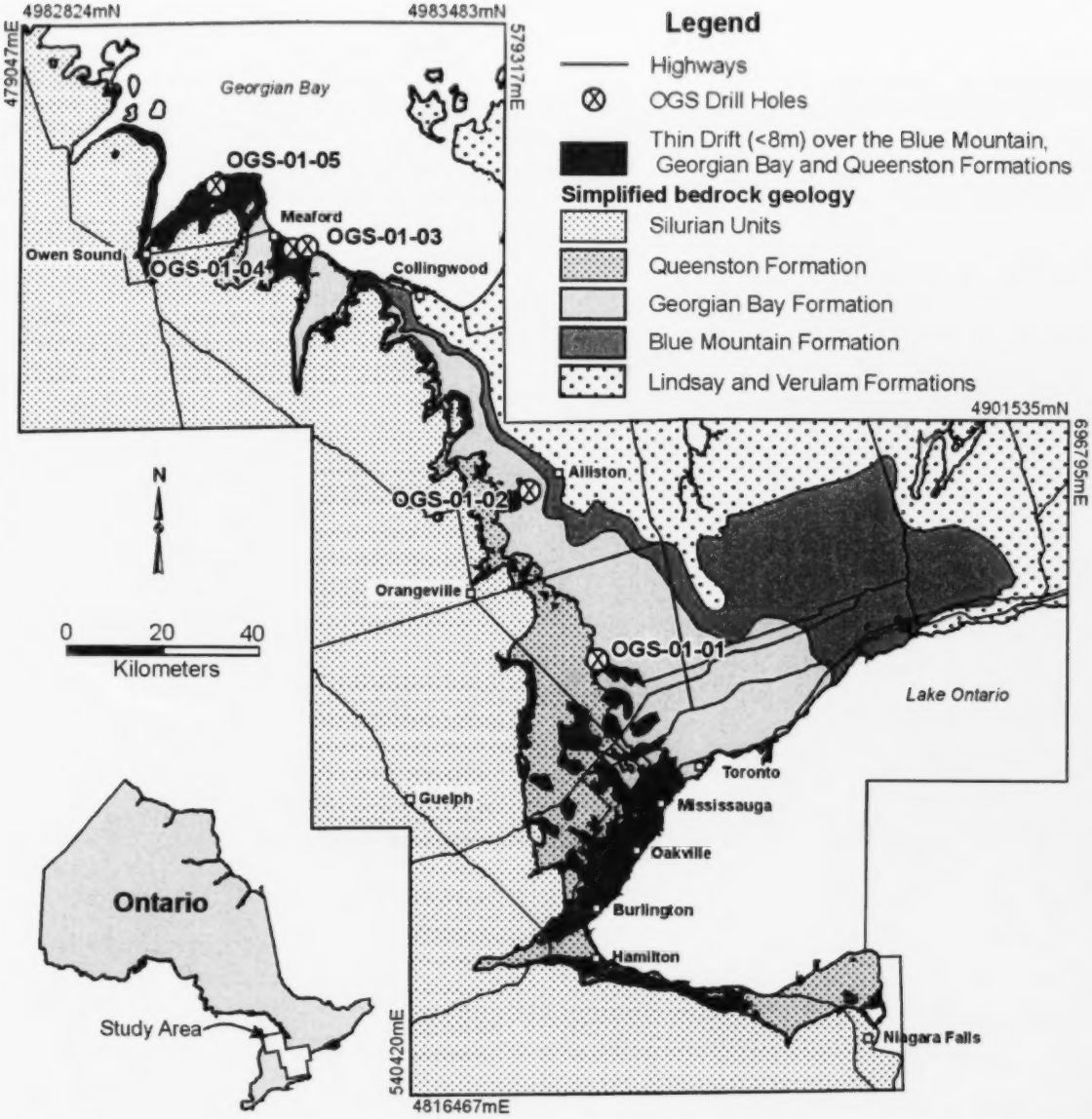

Figure 2: Generalized bedrock geology map of south-central Ontario, highlighting the distribution of the Queenston, Georgian Bay and Blue Mountain formations, areas of thin drift over these units, and locations of the 2001 OGS drill holes (*after* Armstrong 2001b; for more detail and for original sources of geology and drift thickness data *see* Figure 1 (back pocket)).

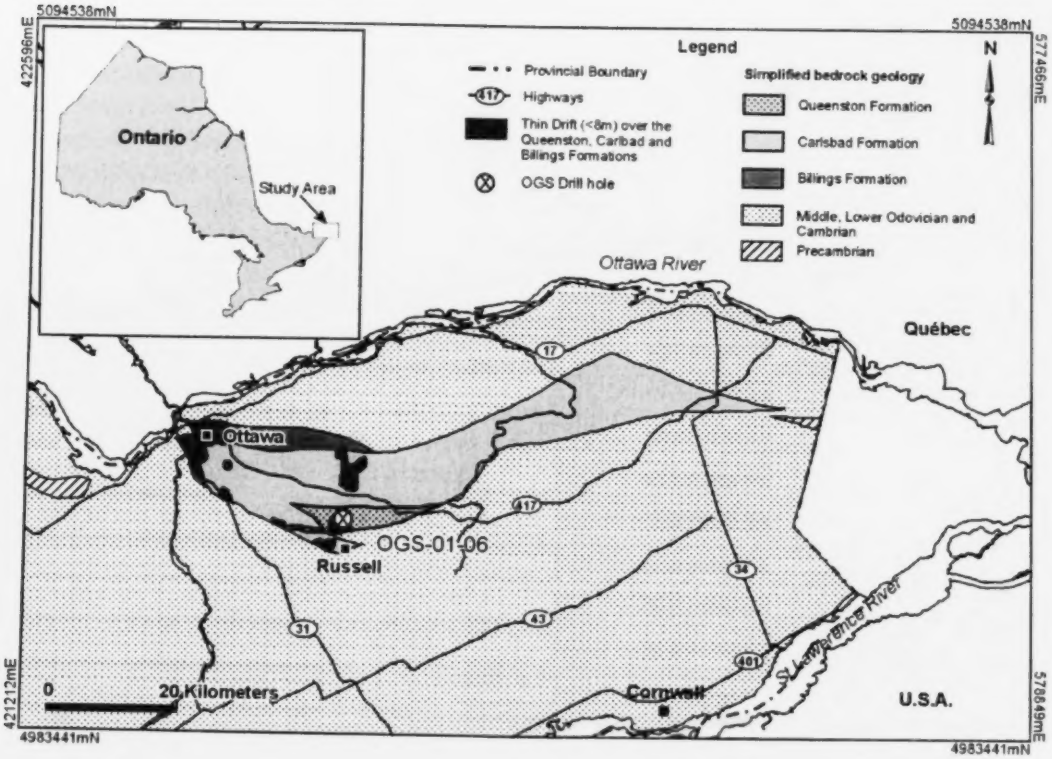

Figure 3: Generalized bedrock geology map of eastern Ontario, highlighting the distribution of the Queenston, Carlsbad and Billings formations, areas of thin drift over these units, and the location of OGS drill hole OGS-01-06 (for geology and drift thickness data sources *see* Figure 1 (back pocket)).

Field mapping stations and drill holes were assigned consecutive station numbers from 01DKA-001 through to 01DKA-0035, and samples were correspondingly numbered (e.g., 01DKA001a, 01DKA001b, etc.) as per the convention described by Armstrong (2001b). Locations of all 2001 stations are listed in Appendix 1 and plotted in Figure 1 (back pocket). A few mapping stations consist of a series of outcrops along creeks or rivers. Composite sections were constructed for these multiple outcrop stations by measuring elevations from outcrop to outcrop by hand level and locating outcrops with a GPS.

Outcrop and drill hole sections were measured and subdivided into lithologic units. These units were numbered from the base upwards for outcrops and from the top down for drill holes. Lithologic unit numbers were used as a guide for constraining geochemical sampling at an individual section and are only of local significance.

Composite samples were obtained from 2 quarries, an old drill hole (the Duntroon core), and 5 of the new drill holes. Descriptions and sample locations for the composite samples are presented in Appendix 2. Samples of individual beds were obtained at 24 mapping stations and 1 new drill hole. Descriptions and locations for bed samples are presented in Appendix 3. All composite samples were analyzed for major and minor elements and these data are presented in Appendix 4 and in digital format in Armstrong and Sergerie (2002a, 2002b). Most of the bed samples were analyzed for major and minor elements and these data are presented in Appendix 5 and in digital format in Armstrong and Sergerie (2002a, 2002b). A total of 352 samples were analyzed for this phase of the study: 54 bed samples from drill cores, 144 bed samples from outcrops, 147 composite samples from drill cores and 7 composite samples from 2 quarries. In addition, this report presents geochemical results for 7 bed samples obtained in 2000 from Lower Silurian shales.

All geochemical analyses were conducted by the Ontario Geoscience Laboratories. Major element oxide content was determined using X-ray fluorescence (XRF) and carbon (reported as CO_2) and sulphur (S) content were determined by infrared (IR) spectroscopy. Bed samples from drill hole OGS-01-06 (station 01DKA-035) and drill hole OGS-00-C1 (station 00DKA-053; Armstrong 2001b) were also analyzed for a large suite of trace and minor elements by ICP-AES and ICP-MS. These data are presented in Table 6-11 in Appendix 6 and in Armstrong and Sergerie (2002a, 2002b).

A total of 121 Queenston Formation samples obtained in 2000 were analyzed for chlorine (Cl) and fluorine (F) using a selective ion electrode method. A total of 85 composite samples were analyzed, including 52 samples from 5 drill cores and 12 samples from 4 outcrops, and 21 samples from 3 quarries. A total of 36 bed samples were analyzed from 3 quarries. The Cl and F data are presented in Appendix 7. Sample locations and descriptions were previously reported in Armstrong (2001a, 2001b).

Nine drill core samples of Queenston Formation shale were submitted to the National Brick Research Center (NBRC) in Anderson, South Carolina, for standard firing and properties testing. The ceramic testing procedures and results were reported in Armstrong and Frederic (2001) and are presented later in this report.

Previous Work

Previous studies of the Queenston Formation and its shale resources were reviewed by Armstrong (2001b). The geology of the all of the Upper Ordovician shale units in Ontario was recently reviewed by Hamblin (1998, 1999). Regional stratigraphic studies which discuss these units, include reports by Liberty (1969), Liberty and Bolton (1971) and Russell and Telford (1983) for south-central Ontario, and Wilson (1964) and Williams (1991) for southeastern Ontario.

The most recent academic studies of the Queenston Formation in Ontario include those by Brogly, Martini and Middleton (1998), Brogly (1984, 1990) and Donaldson (1989a, 1989b). Recent similar studies of the Georgian Bay Formation include those by Flach (1985), Byerley and Coniglio (1989, 1991), Kerr and Eyles (1991) and Stanley and Pickerill (1998). The poorly exposed Blue Mountain Formation is the least studied of the units considered within this report.

The industrial mineral potential of the Upper Ordovician shales in Ontario has been the subject of numerous studies spanning almost a century. Significant reports include those by Baker (1906), Keele (1924), Montgomery (1930), Brady and Dean (1966), Guillet (1964, 1967, 1977), Vos (1975), Kwong, Martini and Narain (1985), Martini and Kwong (1986), Guillet and Joyce (1987) and Rutka and Vos (1993). Telford and Narain (1980) also reviewed the industrial mineral potential of the Niagara Escarpment area.

The south-central Ontario area of the present study has been covered by a number of federal and provincial survey Paleozoic bedrock geology maps at various scales, including: Liberty (1969), Liberty and Bolton (1971), Ontario Geological Survey (1991b), Bond and Telford (1976), Bond, Liberty and Telford (1976), Liberty, Bond and Telford (1976a, 1976b, 1976c), Liberty, Feenstra and Telford (1976a, 1976b), Telford (1976a, 1976b), Feenstra (in preparation), Armstrong (1993) and others. A composite of these maps has been constructed for this study and forms the foundation of Figure 1 (back pocket) and other map figures in this report. In eastern Ontario, the outcrop and subcrop areas of the Upper Ordovician shales is covered by OGS mapping by Williams, Rae and Wolf (1984, 1985a, 1985b, 1985c).

Geological Overview

PALEOZOIC STRATIGRAPHY

During the Late Ordovician, the Taconic Orogeny (ancestral Appalachian Mountains) shed a large wedge of clastic sediments into the Appalachian Basin and beyond. In southern Ontario, this shale-dominated succession is subdivided into the Blue Mountain, Georgian Bay and Queenston formations (Table 1; Liberty 1969; Russell and Telford 1983; Johnson et al. 1992). These units outcrop east of and below the Niagara Escarpment (Figures 1a (back pocket) and 2) and extend in the subsurface from there to the southwest. The equivalent units in eastern Ontario, the Billings, Carlsbad and Queenston formations (Table 1), occur in down-dropped fault-blocks which extend eastward from Ottawa to the Québec border (Figures 1b (back pocket) and 3; Williams 1991; Williams and Telford 1986). In both areas, these formations reflect an upward succession of shallower depositional environments: from the open marine, grey shales of the Blue Mountain and Billings formations, through shallower, storm-influenced, green-grey shales, sandstones and limestones of the Georgian Bay and Carlsbad formations, to very shallow, marginal marine to possibly terrestrial, red, silty shales of the Queenston Formation (Johnson et al. 1992; Hamblin 1998, 1999).

The Blue Mountain Formation ranges from 35 to 75 m thick (Hamblin 1999) and consists mainly of grey to blue-grey, non-calcareous shale or mudstone with thin, discontinuous, limestone, siltstone and fine-grained sandstone beds. The siltstones and sandstones, are commonly calcareous and may actually be calcisiltites and calcarenites (i.e., composed mainly or entirely or silt- or sand-sized carbonate grains). They are commonly planar to low angle laminated, with rippled tops. Limestone beds occur as thin, bioclastic beds, some of which are only one fossil (typically crinoid fragments) thick. Fossils include crinoids, graptolites and brachiopods. Shallowing-upward packages have been recognized within the Blue Mountain Formation (A.P. Hamblin, Geological Survey of Canada, personal communication, 2001). These packages range from 5 m to tens of metres in thickness and consist of mudstone with an upward-increasing proportion of non-shale (e.g., siltstone, sandstone and/or limestone) interbeds.

The Georgian Bay Formation consists of 125 to 250 m (Hamblin 1999) of grey to green-grey shales or mudstones with interbeds of calcareous siltstone, sandstone and limestone. The abundance and thickness of these non-shale interbeds is typically greater in the Georgian Bay Formation as compared to the Blue Mountain Formation, and the contact between these 2 formations is conformable, gradational and arbitrary. Johnson et al. (1992) defined the base of the Georgian Bay Formation to be at the base of the lowest hard band greater than 5 cm thick. However, the lateral thinning and pinch-out of individual beds makes outcrop to outcrop correlation of a formational contact difficult. In this study, this inter-formational contact was selected arbitrarily based on the general upward increase in abundance of hard beds and placed at the base of an interval of interbedded shale and hard beds. Therefore, isolated hard beds up to 15 cm thick were included in the Blue Mountain Formation.

As in the Blue Mountain Formation, the siltstones and sandstones in the Georgian Bay Formation are commonly calcareous and may, in many cases, be calcisiltites and calcarenites. They also commonly contain horizontal to low angle lamination, rippled tops, planar bases, bioclastic lags and graded bedding (fining upwards). Fossils are abundant in the Georgian Bay Formation and commonly include brachiopods, bryozoans, bivalves, gastropods, cephalopods and trilobites (Rudkin et al. 1998). Limestones are typically bioclastic and very fossiliferous. Shallowing-upward cycles have also been recognized in the Georgian Bay Formation (A.P. Hamblin, Geological Survey of Canada, personal communication, 2001), however, they tend to be thinner than the Blue Mountain, ranging from a few metres to 10 m in thickness.

The Queenston Formation, characterized by red shales, outcrops (or subcrops beneath Quaternary drift) in a narrow belt immediately east and north of the Niagara Escarpment (Figures 1a (back pocket and 2). From there, it extends beneath younger Paleozoic bedrock units into the subsurface of southwestern Ontario (Sanford 1961). It is also found in a small outlier in a down-thrown fault-block in eastern Ontario (Williams and Telford 1986). In the vicinity of its main outcrop belt, the formation ranges from over 300 m thick beneath the eastern end of Lake Erie to less than 50 m thick at the north end of the Bruce Peninsula (Sanford 1961). In the central part of the main study area (i.e., south-central Ontario), from Hamilton to Orangeville, it thins from approximately 180 to 120 m (Sanford 1961).

The Queenston Formation conformably overlies the Georgian Bay Formation and is sharply overlain by Lower Silurian units (Johnson et al. 1992). In the Niagara Peninsula and northwards to near Collingwood, it is sharply overlain by sandstones of the Whirlpool Formation. Northwest of Collingwood, the Queenston Formation is overlain by limestones and dolostones of the Manitoulin Formation (Table 1). The upper contact of the Queenston Formation has been called an unconformity (e.g., Johnson et al. 1992; Martini and Kwong 1986). However, there is some uncertainty – due in part to the paucity of biostratigraphically significant fossils in the upper Queenston – as to the amount of time missing at this contact, either through non-deposition or erosion (Hamblin 1999), and so the term disconformity may be more appropriate.

The Lower Silurian Cabot Head Formation shales outcrop in a narrow belt along the base of the Niagara Escarpment. This formation gradationally overlies the Whirlpool Formation or the Manitoulin Formation (Table 1). On the Niagara Peninsula, it is gradationally overlain by sandstones and shales of the Grimsby Formation. Between the Niagara Peninsula and Georgian Bay, it is sharply overlain by dolostones of the Reynales or Fossil Hill formations. On the Bruce Peninsula and Manitoulin Island, the Cabot Head Formation is gradationally overlain by dolostones of the Dyer Bay Formation. The Cabot Head Formation ranges from 10 to 40 m in thickness and consists of maroon to green to grey, non-calcareous shales with minor calcareous sandstone, dolostone and limestone interbeds (Johnson et al. 1992).

The Lower Silurian Wingfield Formation gradationally overlies the Dyer Bay Formation and consists of up to 15 m of interbedded olive-green, non- to slightly calcareous shales and thin-bedded, brown, argillaceous dolostones (Johnson et al. 1992). The Wingfield Formation is exposed in a narrow outcrop belt along the Niagara Escarpment on the Bruce Peninsula and on Manitoulin Island.

DRIFT COVER

One of the key factors governing the economic potential of a bedrock resource is the thickness of drift cover. Areas of thin drift (less than 8 m thick) underlain by the Blue Mountain, Georgian Bay and Queenston formations and their equivalents in eastern Ontario are highlighted in Figures 1 (back pocket), 2 and 3.

The largest areas of thin drift over these shale units occur in heavily urbanized areas west of Toronto and along the Niagara Peninsula, east of Hamilton. Small thin drift areas over the Queenston Formation occur sporadically along the Niagara Escarpment, and thus lie mainly within the Niagara Escarpment Plan Area (NEPA). In the central part of the Upper Ordovician shale outcrop belt, from northwest of Toronto to south of Collingwood, these units are covered by thick Quaternary deposits, with only small thin drift areas located in the vicinity of Alliston, Mansfield and Duntroon. Relatively large areas of thin drift over these units are located south and west of Meaford. Only small areas of thin drift cover occur over these units in eastern Ontario (Figures 1b (back pocket) and 3).

In eastern Ontario, the equivalent units to the Blue Mountain, Georgian Bay and Queenston formations, are the Billings, Carlsbad and Queenston formations, respectively (Table 1). Lithologically, these units are grossly similar to their counterparts in southern Ontario (*see* Williams 1991; Johnson et al. 1992).

Geochemical Results

Major and minor element geochemistry is useful in helping to identify lithologic characteristics, potential deleterious components and as an initial screen to evaluate resource quality. Follow-up work involving ceramic testing is required for definitive shale resource evaluation for heavy clay industry applications.

BED SAMPLES

Individual bed or spot samples were analyzed in order to characterize the lithologic constituents of each formation. Systematically obtained (e.g., every 3 m along a drill core) bed samples may also be useful in characterizing the geochemistry of a lithostratigraphic unit. A total of 198 bed samples were analyzed for this phase of the shale study: 54 samples from one drill core (OGS-01-06) and 144 from outcrops. The rock type of each sample was identified as either shale, non-shale (includes limestone, siltstone and sandstone) or mixed. Bed sample locations and descriptions are presented in Appendix 3 and their analytical results are presented in Appendix 5.

Queenston Formation

A total of 62 bed samples were obtained for geochemical analysis from the Queenston Formation in the 2001 field season. Of these, 49 were identified as shale and 13 as non-shale (e.g., limestone, siltstone, etc.). Of the 49 shale samples, 33 were red shales and 4 were green and 12 were mixed green and red. Average content and ranges for selected elemental contents for these various lithologic sample types are presented in Tables 3 and 4.

Armstrong (2001b) determined that, for the Queenston Formation, CO_2 content is a good indicator of carbonate (i.e., calcite) content. Based on CO_2 content, non-shale beds tend to be more calcareous than shales (Table 3) and green shales tend to be more calcareous than red shales (Table 4). These relationships, as well as elemental averages for the whole formation ("all samples" *in* Table 3), are generally similar to those determined for the 2000 data set (Table 2 *in* Armstrong 2001b).

Bed samples were also obtained from the Queenston Formation in drill hole OGS-01-06, drilled at the Russell Quarry in eastern Ontario. Analysis of these samples are reported in a later section of this report.

Table 3: Summary of selected geochemical results for all 2001 Queenston Formation bed samples from outcrops. Full data set presented in Appendix 5. "n.d." = not detected.

		SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
all samples (n = 62)	**average**	**44.96**	**12.77**	**3.71**	**12.90**	**5.43**	**10.89**	**0.01**	**0.72**
	minimum	20.02	5.73	2.00	3.59	1.93	2.93	n.d.	0.07
	maximum	59.42	16.32	7.92	35.14	8.04	26.10	0.05	2.37
shale samples (n=49)	**average**	**46.06**	**13.85**	**3.72**	**11.11**	**6.06**	**9.47**	**0.01**	**0.85**
	minimum	35.66	9.10	2.68	3.59	3.44	2.93	n.d.	0.18
	maximum	58.01	16.32	7.59	23.20	8.04	19.40	0.05	2.37
non-shales (n=13)	**average**	**40.78**	**8.73**	**3.69**	**19.67**	**3.05**	**16.25**	**0.02**	**0.23**
	minimum	20.02	5.73	2.00	7.19	1.93	6.07	n.d.	0.07
	maximum	59.42	12.79	7.92	35.14	4.81	26.10	0.04	0.57

Table 4: Summary of selected geochemical results for 2001 Queenston Formation red and green shale bed samples from outcrops (n=37). Full data set presented in Appendix 5. "n.d." = not detected.

		SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
red shales (n=33)	**average**	**47.78**	**14.40**	**3.49**	**9.77**	**6.56**	**8.14**	**0.01**	**1.02**
	minimum	36.53	11.65	2.81	3.59	5.36	2.93	n.d.	0.38
	maximum	57.93	16.32	6.15	18.84	8.04	14.60	0.02	2.37
green shales (n=4)	**average**	**43.84**	**13.07**	**4.62**	**12.98**	**4.25**	**11.97**	**0.02**	**0.38**
	minimum	39.02	10.92	2.68	9.18	3.44	8.57	0.01	0.23
	maximum	50.41	14.41	7.59	19.12	4.84	14.80	0.05	0.49

Georgian Bay Formation

A total of 56 bed samples were obtained for analysis from outcrops of the Georgian Bay Formation in the 2001 field season. Of these, 42 were identified as shale samples, 11 as non-shale samples and 3 as mixed shale and non-shale. The geochemistry of these samples is summarized in Table 5. Overall this formation is less calcareous (lower CO_2 and CaO values) than the Queenston Formation. Specifically, Georgian Bay shales are non- to slightly calcareous and non-shale beds include a range from non-calcareous sandstones and siltstones to limestones. Sulphur content is also generally higher in the Georgian Bay Formation than in the Queenston Formation.

Table 5: Summary of selected geochemical results for all 2001 Georgian Bay Formation bed samples from outcrops. Full data set presented in Appendix 5.

		SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
all samples (n=56)	**average**	**57.14**	**15.04**	**3.27**	**4.53**	**6.29**	**4.47**	**0.29**	**2.34**
	minimum	25.80	5.54	1.31	0.59	2.71	0.67	0.01	0.16
	maximum	64.79	18.22	4.17	30.39	7.76	25.80	1.29	9.60
shale samples (n=42)	**average**	**57.89**	**16.71**	**3.43**	**2.44**	**6.76**	**2.72**	**0.30**	**2.87**
	minimum	52.78	13.51	2.79	0.59	5.32	0.67	0.01	1.39
	maximum	63.27	18.22	4.17	4.47	7.76	4.99	0.90	9.60
non-shales (n=11)	**average**	**54.99**	**8.64**	**2.72**	**12.06**	**4.52**	**10.89**	**0.25**	**0.57**
	minimum	25.80	5.54	1.31	4.51	2.71	4.68	0.03	0.16
	maximum	64.79	11.60	3.83	30.39	6.20	25.80	1.29	1.13

To investigate regional variability of lithologic constituents within the Georgian Bay Formation, 12 shale and non-shale bed samples (6 each) were analyzed from 3 drill cores (4 samples from each core) located in the southern, central and northern parts of this formation's outcrop belt (Table 6). From south to north, the drill holes sampled are OGS-01-01, OGS-01-02 and OGS-01-05 (locations plotted in Figures 1a (back pocket) and 2).

The overall differences in geochemistry of shales versus non-shales (Table 6) is similar to that determined for the larger field sample data sets (Table 5). The shale samples exhibit no distinct geographic trends. The non-shale samples, however, are more calcareous (higher CO_2 and CaO) towards the north.

Determining potential stratigraphic trends in the geochemistry of these lithologic components is not possible with this small data set, because the stratigraphic position of the intervals intersected by cores OGS-01-01 and OGS-01-02 is not known and the 3 holes are too far apart.

Table 6: Selected element content averages for shale and non-shale Georgian Bay Formation bed samples from 3 drill cores (OGS-01-01, OGS-01-02, OGS-01-05). Full data sets and sample information are presented in Appendix 6.

Sample Group (#)	SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
all shale samples (n=6)	54.65	16.23	3.95	3.70	6.71	4.03	0.33	2.23
all non-shale samples (n=6)	52.00	9.01	2.60	13.60	3.55	11.89	0.17	0.32
OGS-01-01 shales (n=2)	57.00	15.32	3.26	3.82	6.49	3.52	0.27	1.89
OGS-01-02 shales (n=2)	55.43	17.56	3.68	2.41	7.35	2.53	0.23	3.28
OGS-01-05 shales (n=2)	51.51	15.83	4.90	4.87	6.29	6.03	0.48	1.53
OGS-01-01 non-shales (n=2)	59.27	8.07	2.52	10.44	3.81	9.34	0.23	0.42
OGS-01-02 non-shales (n=2)	50.51	9.41	2.05	14.83	4.24	12.65	0.09	0.33
OGS-01-05 non-shales (n=2)	46.22	9.54	3.23	15.54	2.61	13.69	0.19	0.20

Blue Mountain Formation

The Blue Mountain Formation bed sample data set consists of 25 shale samples and 6 non-shale samples. Five of the shale samples were obtained from core drilled by Ontario Power Generation (OPG) in 2000 in the floor of the Rouge River valley, east of Toronto (Armstrong 2000b). This data set is summarized in Table 7.

The Blue Mountain Formation has a higher average sulphur content than both the Georgian Bay and Queenston formations (*cf.* Tables 3, 5 and 7). Although, the carbonate content (based on CO_2 values) of the Blue Mountain Formation (Table 7) appears to be higher than the Georgian Bay For .iation (Table 5), comparable CaO values indicate little difference in carbonate content. Elevated CO_2 values may reflect the higher organic carbon content of samples from the Rouge River valley samples which represent a stratigraphically lower, more organic-rich part of the Blue Mountain Formation (i.e., the Rouge River Member). Southern (i.e., Rouge River area) and northern (i.e., Meaford area) shale samples are geochemically compared in Table 8.

Table 7: Summary of selected geochemical results for all 2001 Blue Mountain Formation bed samples (n=31). Full data set presented in Appendix 5.

		SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
all samples (n=31)	**average**	**55.00**	**15.83**	**3.36**	**4.33**	**6.64**	**6.10**	**0.75**	**1.71**
	minimum	12.04	3.79	2.12	1.42	4.57	2.18	0.22	0.18
	maximum	61.13	18.17	7.26	32.37	7.92	40.40	1.96	3.19
shale samples (n=25)	**average**	**56.66**	**16.92**	**3.25**	**2.54**	**6.78**	**4.45**	**0.76**	**1.92**
	minimum	51.21	13.92	2.74	1.42	5.88	2.18	0.22	0.55
	maximum	59.21	18.17	3.67	5.24	7.92	13.40	1.96	3.19
non-shales (n=6)	**average**	**48.07**	**11.30**	**3.82**	**11.76**	**6.04**	**12.97**	**0.71**	**0.86**
	minimum	12.04	3.79	2.12	2.56	4.57	3.22	0.49	0.18
	maximum	61.13	17.38	7.26	32.37	7.15	40.40	1.01	2.16

Table 8: Geochemical comparison of northern (Meaford area) and southern (Rouge River area) Blue Mountain Formation shale samples. Complete data set in Appendix 5.

		SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
northern shale (n=16)	**average**	**57.79**	**16.84**	**3.36**	**2.30**	**6.69**	**3.07**	**0.67**	**2.32**
	minimum	54.20	13.92	3.17	1.42	5.88	2.18	0.28	1.06
	maximum	59.21	18.17	3.67	5.24	7.32	5.57	1.08	3.19
southern shale (n=9)	**average**	**54.65**	**17.06**	**3.06**	**2.97**	**6.94**	**6.91**	**0.93**	**1.22**
	minimum	51.21	15.60	2.74	2.13	6.03	3.23	0.22	0.55
	maximum	56.88	17.62	3.30	4.86	7.92	13.40	1.96	2.06

Lower Silurian Units

In 2000, 7 samples of shale were obtained from outcrops of 2 Lower Silurian shale-dominated formations. Six bed samples were obtained from 3 outcrops of the Cabot Head Formation on the Bruce Peninsula and 1 sample of the Wingfield Formation from an outcrop located at Lion's Head on the Bruce Peninsula. Outcrop locations are presented in Armstrong (2001c) . Sample descriptions and data are presented in Appendixes 3 and 5, respectively, and in Armstrong and Sergerie (2002a). A summary of the data for selected elements is presented in Table 9. The Cabot Head Formation samples exhibit a relatively wide range of composition that, within this small data set, appears to be related to colour of shale. Red shale samples have lower CaO and CO_2, suggesting lower carbonate content relative to green shale samples (*see* Appendixes 3 and 5). High MgO and CO_2 values for the Wingfield Formation sample suggest a high dolomite content.

Table 9: Summary of selected geochemical data for 2000 Lower Silurian shale bed samples. Full data set presented in Appendix 5. "n.d." = not detected.

		SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
Cabot Head Fm samples (n=6)	**average**	**52.52**	**16.42**	**3.52**	**2.38**	**6.38**	**3.29**	**0.25**	**3.49**
	minimum	45.90	12.16	1.81	0.98	5.01	1.16	n.d.	0.91
	maximum	58.27	19.66	4.94	4.06	8.37	5.93	1.24	6.59
Wingfield Fm (n=1)		30.44	9.20	12.44	15.13	2.63	23.10	0.13	0.11

COMPOSITE SAMPLES

Composite or continuous channel samples were analyzed in order to geochemically characterize lithologic units and whole sections. To obtain an average elemental content over an interval covered by a number of composite samples (e.g., over a whole section or drill hole), the composite sample data must be weighted according to their respective individual sample interval lengths or heights. Weighted averages are calculated for each element analyzed, by multiplying composite sample data by their respective sample interval height (or length), summing these values for each element over the interval to be averaged, and then dividing each of these elemental sums by the height of the interval to be averaged. Composite sample data give a more accurate picture of the bulk chemistry of the formation at a particular locality.

A total of 61 composite samples were obtained for analysis from 2 quarries and a previously drilled core, OGS-80-1, from the Duntroon Quarry (sample locations and descriptions are presented in Appendix 2). All except one of these samples were of the

Queenston Formation. Composite sample data are presented in Appendix 4. In addition, 92 composite samples were obtained from 5 of the 2001 OGS drill holes:
8 samples from the Queenston Formation (drill holes OGS-01-04 and -05);
69 samples from the Georgian Bay Formation (drill holes OGS-01-01, -02, -04, -05); and
15 samples from the Blue Mountain Formation (drill hole OGS-01-03).
Sample information and geochemical data are presented in Table 6-9 of Appendix 6 and in Armstrong and Sergerie (2002b). Weighted averages calculated for formational intervals in these cores were averaged to yield averages for each formation (Table 10). Note that these are small, geographically and stratigraphically limited data sets, and should not be used to infer average compositions for entire formations. However, general trends observed in the bed sample data sets (Tables 3, 5 and 7), such as downward (i.e., from Queenston to Blue Mountain formations) decreasing carbonate content (indicated by CaO and CO_2) and increasing sulphur content, are confirmed in the composite sample data set (Table 10).

Composite sample geochemical data, plotted versus height for quarries or outcrops or versus depth for drill core, provide a visual representation of vertical geochemical variability within individual sections. Plots such as these are used in later sections of this report.

Table 10: Average values of selected elements for composite samples grouped by formation from 2001 OGS drill holes. Values are averages of weighted averages (see text for weighting method) calculated for each set of core samples. Full data set is presented in Appendix 6.

	SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
Queenston Fm samples	43.58	11.13	5.25	13.33	4.84	13.51	0.10	0.38
Georgian Bay Fm samples	53.27	14.25	3.55	6.92	6.03	6.49	0.17	1.18
Blue Mountain Fm samples	56.13	16.56	3.37	3.06	6.81	3.69	0.74	1.87

CHLORINE AND FLUORINE DATA

Chlorine and fluorine are considered potential environmentally hazardous elements in the brick-making process (Rutka and Vos 1993; Guillet and Joyce 1987). Bed and composite samples from outcrops, quarries and drill core samples of the Queenston Formation were analyzed for chlorine and fluorine. The complete data sets are presented in Appendix 7. They included 36 bed samples from 3 quarries (the Burlington, Cheltenham and Milton quarries) and 85 composite samples from 3 outcrops, 4 quarries and 5 drill cores. Chlorine contents were below detection (i.e., less than 250 ppm) for almost all of the samples analyzed. Summaries of the fluorine data are presented in Tables 11 and 12.

Table 11: Summary of fluorine content (ppm) in bed samples of Queenston Formation samples. See Appendix 7 for full data set.

Rock Type:	shale	non-shale	mixed
Average	961	608	692
Minimum	825	400	450
Maximum	1125	900	900
Number of Samples	16	13	6

Table 12: Summary of fluorine (F) data (weighted averages – see text for weighting method) for Queenston Formation composite samples from outcrops (o), quarries (q), and OGS drill holes (d). Full data set is presented in Appendix 7. Note: * average does not include sample 00DKA151O.

Location	Station #	Station Type	Sample Interval (m)	F content (ppm)
Mount Pleasant – Brampton	00DKA-005	o	4.15	842
Georgetown – Credit River	00DKA-011	o	2.85	767
Huttonville – Credit River	00DKA-013	o	1.95	871
Milton Quarry (top part)	00DKA-004	q	9.10	1036
A.C. Martin Quarry	00DKA-006	q	10.00	958
Streetsville Quarry	00DKA-007	q	18.20	787
Aldershot Quarry	00DKA-014	q	18.10	980
drill hole OGS-00-A1	00DKA-145	d	19.43	811
drill hole OGS-00-A6	00DKA-148	d	20.08	838
drill hole OGS-00-B1	00DKA-151	d	24.48	1030*
drill hole OGS-00-B4	00DKA-152	d	11.33	896
drill hole OGS-00-C2	00DKA-154	d	20.33	1172

Fluorine content in the bed samples ranges from 450 to 1125 ppm. The shale bed samples are generally higher in F content with an average of 961 ppm, as compared with 608 ppm for non-shale (i.e., limestones, siltstones and fine-grained sandstones) and 692 ppm for samples with mixed shale and non-shale constituents (Table 11).

Fluorine content in the composite sample data set ranges from below detection (i.e., less than 250 ppm) to 1275 ppm (Appendix 7). One sample, 00DKA151O, from drill hole OGS-00-B1, contains 7225 ppm F; this highly anomalous value was not included in averaging calculations. Generally, fluorine content appears to be highest in samples from the upper part of the Queenston Formation (i.e., average values for the Milton Quarry and drill holes OGS-00-B1 and OGS-00-C2; Table 12). This may be due to the generally higher shale content of this part of the formation.

Chlorine content in composite samples ranged from below detection (i.e., below 250 ppm) for most samples (66 samples), to 950 ppm (725 ppm if sample 00DKA151O is ignored). Only 19 samples had detectable chlorine contents (i.e., greater than 250 ppm). This data set is too small to use for meaningful analysis.

Rutka and Vos (1993) analyzed core samples from the Queenston and Georgian Bay formations. Their data, also presented in Appendix 7 in Armstrong (2001b), is summarized here in Table 13. Their fluorine values are generally lower than the present study, suggesting the differences may be due to different analytical methods. The small 1989 data set of Rutka and Vos (1993) does not exhibit the same upwards-increasing fluorine content as was observed for the more recent data set. There also appears to be no stratigraphic trend in chlorine content.

Table 13: Chlorine (Cl) and fluorine (F) data (in ppm) from 1989 OGS drill holes (*from* Rutka and Vos 1993). Values for each drill hole are weighted averages (see text for explanation of weighting method). Note: "QF" = Queenston Formation; "GB" = Georgian Bay Formation; "n" = number of samples; "n/a" = not analyzed.

OGS drill hole # (Formation) - holes listed in approximate stratigraphic order	n	Interval Represented (m)	Cl (ppm)	F (ppm)
OGS-89-09 (QF)	5	10.97	461	548
OGS-89-05a (QF)	5	11.58	551	523
OGS-89-10 (QF)	3	7.31	152	603
OGS-89-06 (GB)	4	9.44	903	549

Results of Field Work and Drilling Program

This section presents the results by formation of the 2001 field work and drilling program.

BLUE MOUNTAIN FORMATION

The Blue Mountain Formation is generally covered by thick Quaternary drift deposits. Small areas of thin drift are known east of Toronto and along the shore of Georgian Bay, southeast of Meaford (Figures 1a (back pocket) and 2).

In the southern part of the Blue Mountain Formation outcrop belt, thin drift areas have been identified along Lynde and Duffins creeks, east of Toronto (Figures 1a (back pocket) and 2). Outcrops also occur along the Rouge River valley floor. One of these outcrops, station 01DKA-007, located on the east side of the Rouge River, south of Twyn River Road, exposes 2.3 m of grey and black fissile shales, beneath ~5 m of drift in the floor of the river valley. The valley is approximately 40 m deep at this location. In a hole drilled by Ontario Power Generation (OPG) less than 300 m to the west of this outcrop, the basal contact of the Blue Mountain Formation occurs approximately 40 m below ground surface at an elevation of 42.72 m asl (Armstrong 2000b). The Blue Mountain Formation is more organic-rich (cf. CO_2 and CaO contents in Table 8) in this area relative to the northern part of its outcrop belt.

In the northern part of its outcrop belt, the Blue Mountain Formation occurs in a narrow belt along Georgian Bay between Meaford and Collingwood (Telford 1976a). Thin drift areas occur southeast of Meaford and between Thornbury and Collingwood (Figures 1a (back pocket) and 2) with outcrops mainly occurring along creeks flowing into Georgian Bay. In the present study, this formation was studied in 3 outcrops located southeast of Meaford: a series of outcrops along Christie Beach Creek (station 01DKA-024); at the east end of a large shale bluff, called the Southeast Claybanks (station 01DKA-018); and the lower part of East Meaford Creek (also called Workman's Creek) (station 01DKA-019). In addition, subsurface information about the Blue Mountain Formation was obtained by drill hole OGS-01-03 (station 01DKA-032), located on the east side of Christie Beach Road, less than 1 km north of Highway 26, and less than 50 m west of the Christie Beach Creek section.

Christie Beach Creek exposes a series of outcrops that can be combined into a composite section (station 01DKA-024) of at least 35.50 m in height (Figure 4). The base of the measured section is located at an elevation of approximately 180 m asl and about 300 m south of the shore of Georgian Bay. It is possible that lower outcrops may be located between the base of the measured section and Georgian Bay. The Christie Beach Creek section is dominated by grey shale, however, thick (up to 25 cm) calcareous sandstone and limestone beds occur at 25.75 and 29.90 m above the base of the measured section (Figure 4). This section was subdivided into 7 lithologically based units. Bed sample locations are plotted on the composite section in Figure 4 (see Appendix 3 for detailed locations) and contents of selected elements are plotted versus height in Figure 5. The percentage of coarse beds (i.e., non-shale hard beds) in each unit is also plotted on Figure 5.

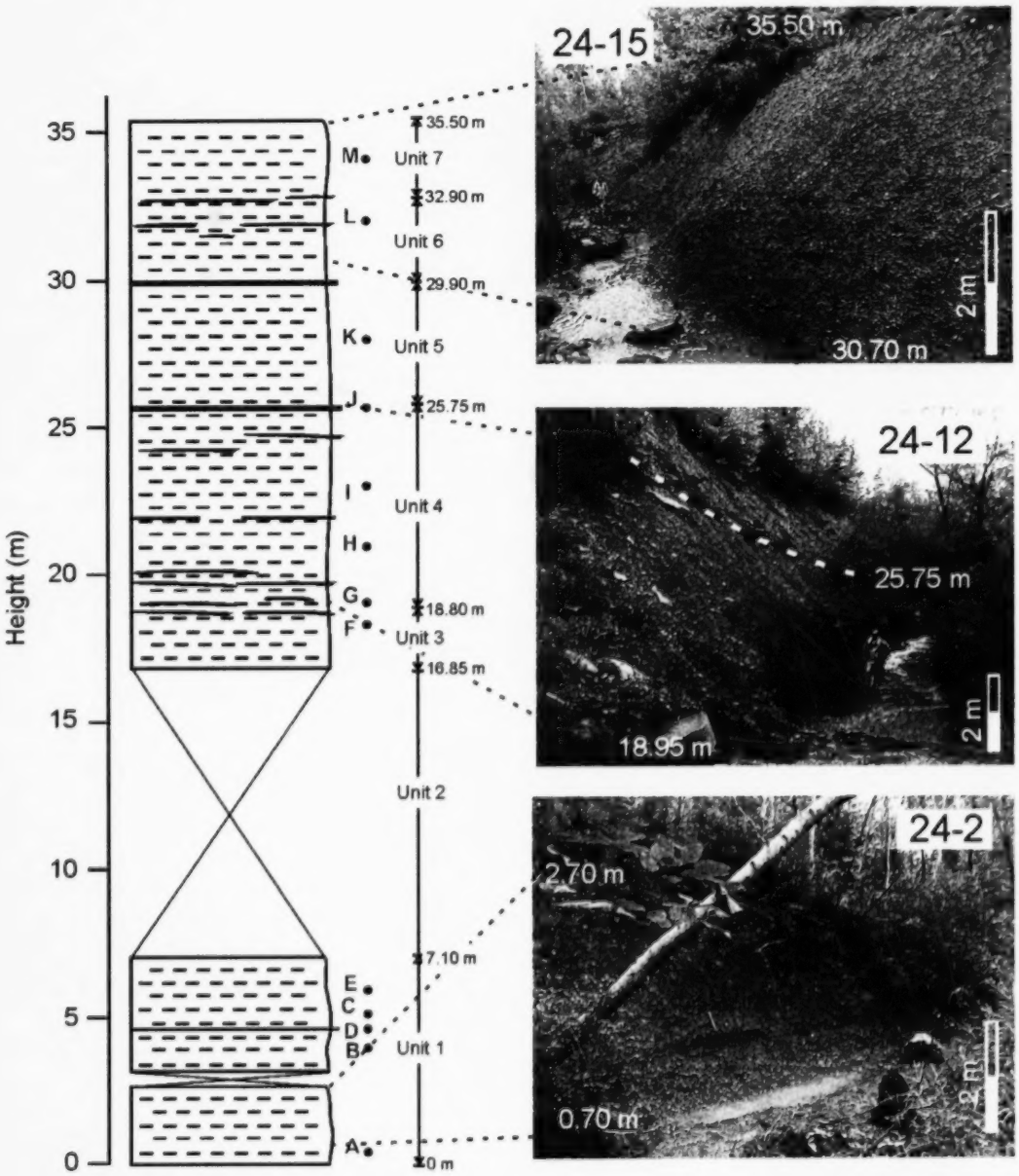

Figure 4: Composite section of 15 Blue Mountain Formation outcrops along Christie Beach Creek (station 01DKA-024), southeast of Meaford. Photo numbers (e.g., "24-15") refer to outcrop number. Labeled dots indicate stratigraphic locations of bed samples (i.e., "M" is location of sample 01DKA024M). Dashed pattern indicates shale, solid lines indicate non-shale hard beds (either limestone, siltstone or sandstone).

Drill hole OGS-01-03, collared approximately 2.2 m above the top of the Christie Beach Creek section, intersected 42.52 m of the Blue Mountain Formation. Fifteen lithologic units were identified in this core and composite samples based on these units (2 samples were taken from some units) were taken for geochemical analysis. A plot of selected elements and percentage coarse beds for this drill hole is presented in Figure 6. Unit descriptions and geochemical data are presented in Tables 6-4 and 6-9 of Appendix 6, respectively. The prominent limestone beds that bound unit 5 in the Christie Beach Creek section can be correlated with bounding beds of unit 3 in OGS-03-01.

The west end of the Southeast Claybanks (station 01DKA-018) rises approximately 46 m above the Georgian Bay shoreline. This section exposes the contact between the Blue Mountain Formation and the overlying Georgian Bay Formation at a height above lake level of approximately 36 m (approximately 212 m asl). The section was subdivided into 8 units, with the lower 4 assigned to the Blue Mountain Formation and the upper 4 to the Georgian Bay Formation. The basal unit, an interval of unknown lithology covered by beach and talus deposits, is overlain by 26.3 m of grey shale with minor hard beds, which are assigned to the Blue Mountain Formation. The topmost 10.25 m of section consists of interbedded grey shale and limestone and is assigned to the Georgian Bay Formation. Figure 7 is a plot of selected element contents in bed samples, percent hard beds and unit contacts versus height above Georgian Bay.

As previously discussed, the transition from Blue Mountain Formation upward into the Georgian Bay Formation is characterized by a general increase in the abundance and thickness of hard beds (non-shale interbeds) and placing the contact is an arbitrary exercise involving selection of a basal "significant" hard bed. Liberty (1969) drew the contact at the base of the lowest occurrence of grey, impure carbonate hard bands overlying the soft, bluish grey shale of the Whitby Formation (now Blue Mountain Formation). Johnson et al. (1992) state that the contact is arbitrarily chosen at the base of the lowest hard bed thicker than 5 cm. The arbitrariness of this criteria is amplified by the fact that hard beds are commonly discontinuous, and so the formational contact may not be laterally consistent from outcrop to outcrop. A more appropriate, albeit still arbitrary, criteria might be the base of a "significant" interval of interbedded shale and hard beds, in approximately equal proportion, that are separated by no more than a few metres from a similar overlying interval.

Taking the regional dip (calculated from the structure contour on top of the lower member of the Lindsay Formation (or top of the Lindsay Formation *sensu* Liberty) (Liberty 1969) to be 9.38 m/km to the west in this area) into consideration, the contact at 36.00 m (base of unit 5) at station 01DKA-018 projects up-dip to an elevation higher than the top of both drill hole OGS-01-03 and the Christie Beach Creek (01DKA-024) section. Even the lower interval of hard beds, unit 3, in the Claybanks projects up-dip to above OGS-01-03. This indicates that the entire sections at Christie Beach Creek and in OGS-01-03 should be assigned to the Blue Mountain Formation.

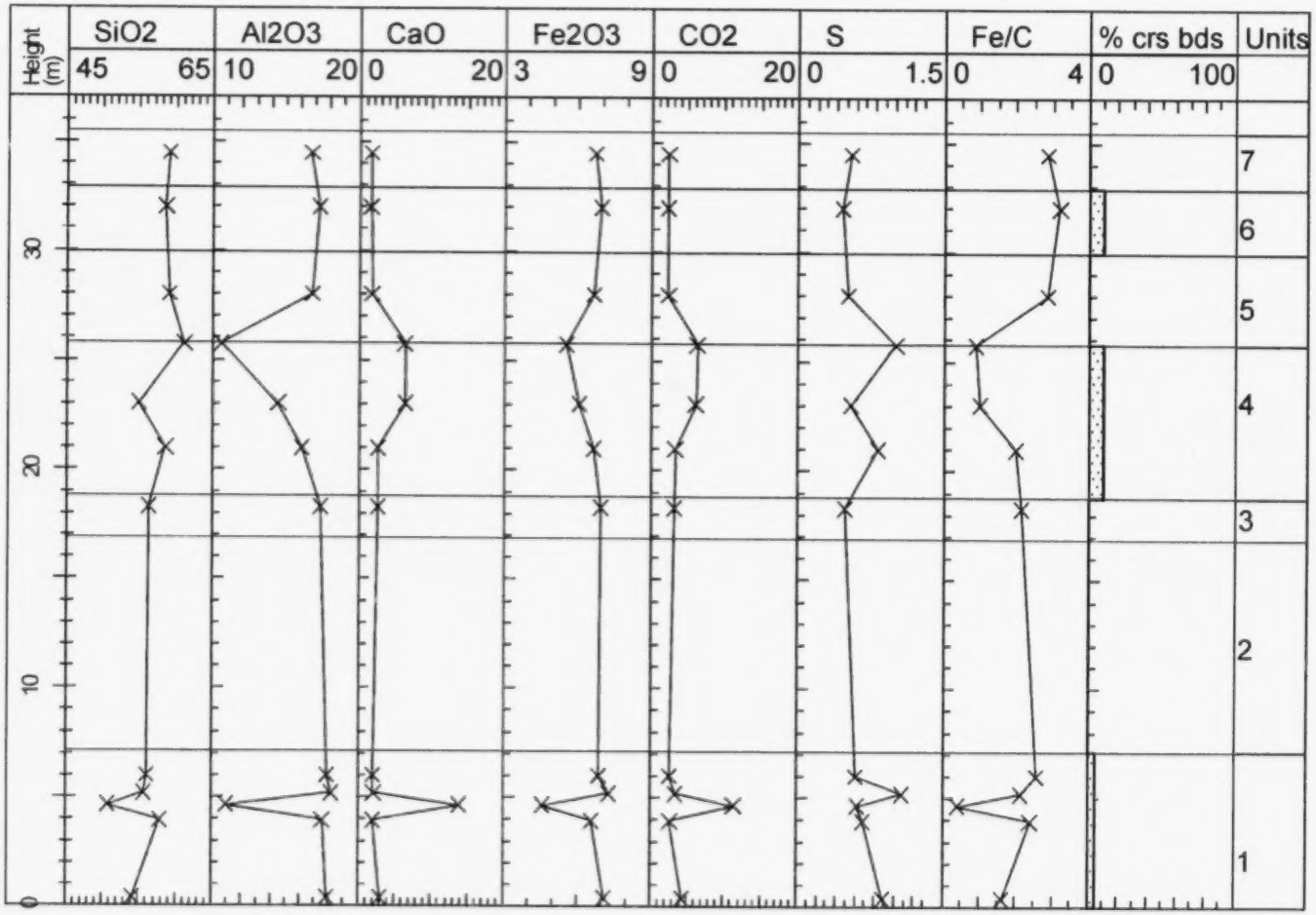

Figure 5: Plot of selected element oxide contents (in weight %) in bed samples from the Christie Beach Creek section (station 01DKA-024). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units. Sample information is presented in Appendix 3 and the complete geochemical data set in Appendix 5.

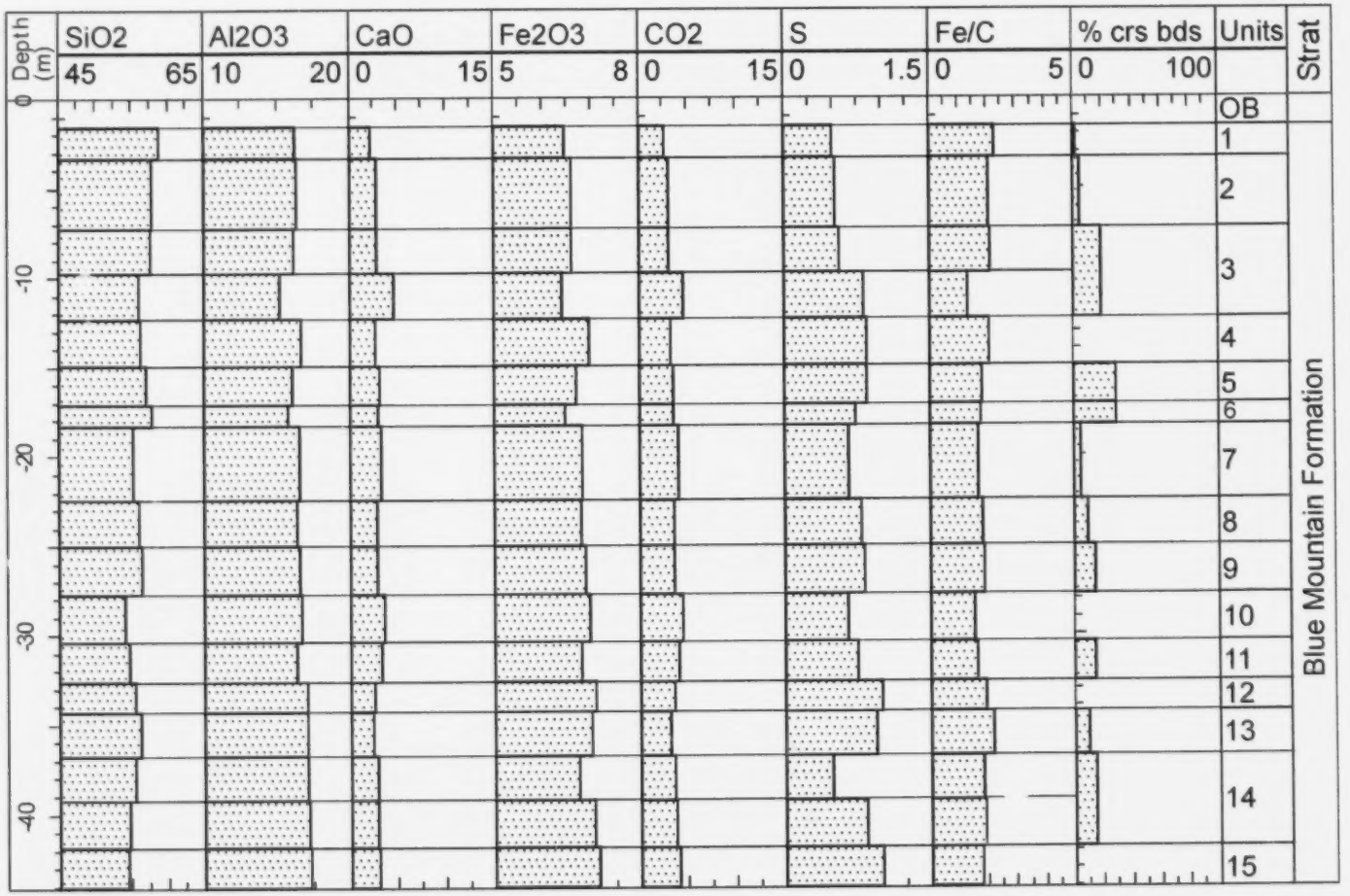

Figure 6: Plot of selected element oxide contents (in weight %) in composite samples from drill hole OGS-01-03 (station 01DKA-032). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units; "Strat" = bedrock stratigraphy. Sample information and geochemical data are presented in Appendix 6.

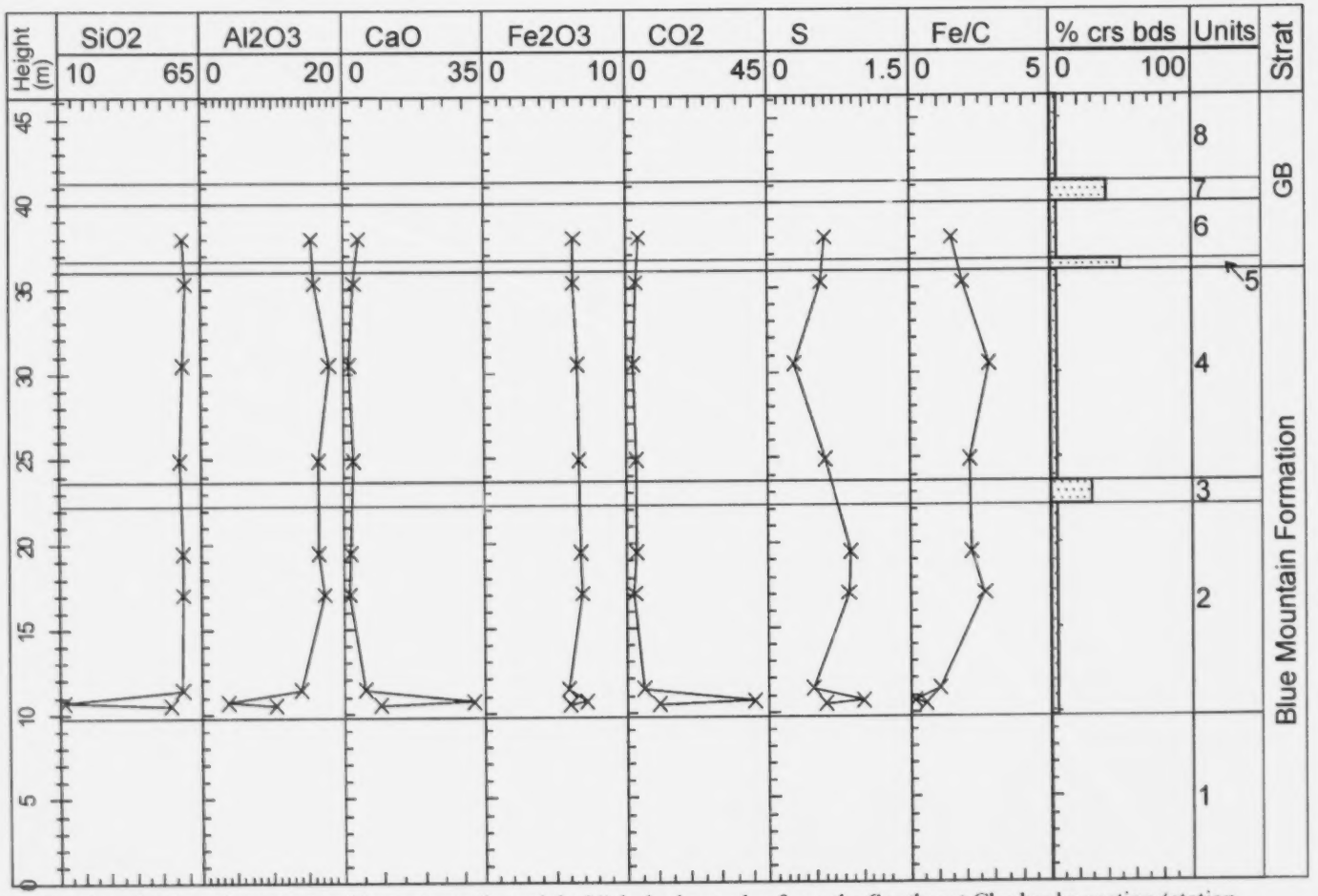

Figure 7: Plot of selected element oxide contents (in weight %) in bed samples from the Southeast Claybanks section (station 01DKA-018). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units; "Strat" = bedrock stratigraphy; "GB" = Georgian Bay Fm. Sample information is presented in Appendix 3 and the complete geochemical data set in Appendix 5.

Projecting the formational contact in the Southeast Claybanks section (01DKA-018) to the east and down-dip towards East Meaford Creek (01DKA-019), corresponds favourably with the base of unit 3, at 29.65 m above lake level, in the latter composite section (Figures 8 and 9). The series of outcrops along East Meaford Creek has been designated as a reference section for the Blue Mountain Formation (upper member of the Whitby Formation (Liberty 1969)) and the type section for the Georgian Bay Formation (Liberty 1969).

Thin drift areas over the outcrop belt of the Billings Formation (Figures 1b (back pocket) and 3), the equivalent unit to the Blue Mountain Formation, are mainly covered by the city of Ottawa. This formation was not investigated for this study.

GEORGIAN BAY FORMATION

The outcrop belt of the Georgian Bay Formation is also largely covered by thick Quaternary drift deposits. Areas of thin drift occur immediately west and northwest of Toronto, and along the shore of Georgian Bay between Collingwood and Owen Sound (Figures 1a (back pocket) and 2). Small areas of thin drift also occur west of Alliston.

In the Toronto area, 6 outcrops along Mimico and Etobicoke creeks, and the Credit and Humber rivers were examined, as well as an outcrop in the inactive Don Valley Brickyard. Station numbers and specific locations are listed in Appendix 1. These sections range up to almost 11 m in height and consist of interbedded grey shale and hard beds. The hard beds consist of calcareous sandstones and siltstones and limestones, generally no more than 25 cm thick, and rarely over 0.5 m thick. Locally (e.g., at stations 01DKA-004 and -008), large soft sediment deformation structures (ball and pillow) are developed in the hard beds. These sections commonly have the appearance of alternating packages of hard bed-rich and hard bed-poor, shale-dominated intervals. The shale-dominated intervals range up to 3 m thick and hard bed-rich intervals range up to 1.5 m in thickness. In some cases, contacts between intervals are sharp and in others they are gradational. In the latter case, both shallowing- and deepening-upwards relationships are recognized and the combined intervals range up to approximately 5 m thick. These Toronto area outcrops are also described in some detail by Kerr and Eyles (1991).

In the Toronto area, the Georgian Bay Formation is mostly covered by urban development. Near Tullamore, northwest of Toronto, and northeast of Brampton an area of thin drift (Figures 1a (back pocket) and 2) was tested with drill hole OGS-01-01 (station 01DKA-030). This hole, drilled on the west side of Goreway Drive, just south of Salt Creek, encountered 1.5 m of overburden and was completed at a depth of 32.00 m. The lithologic log and geochemical data for this core are presented in Tables 6-2 and 6-8, respectively, of Appendix 6. A plot of selected elements versus depth is presented in Figure 10. This plot also shows the distribution of units and percent coarse beds (i.e. non-shale or hard beds).

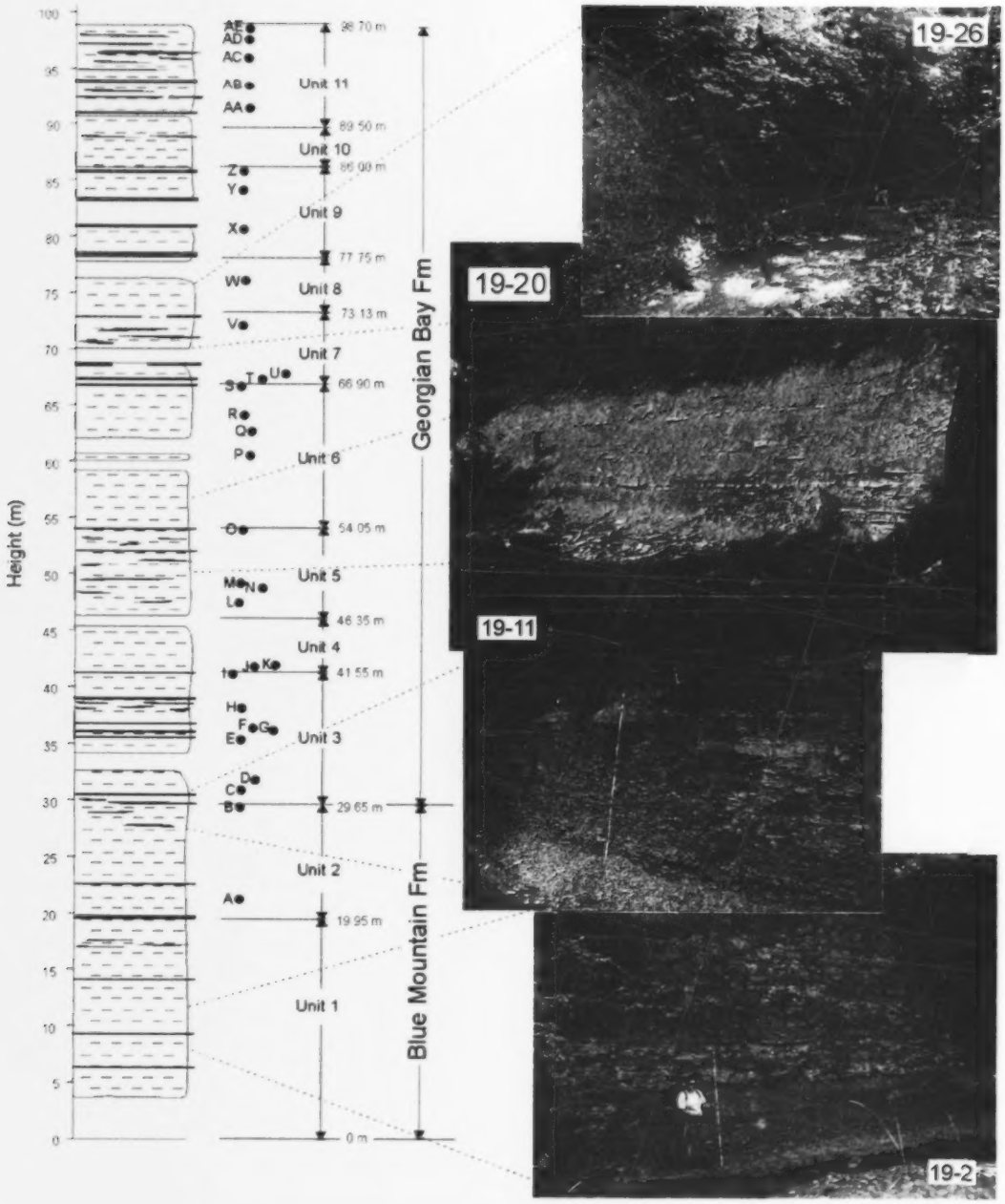

Figure 8: Composite section of 37 outcrops along East Meaford (Workman's) Creek (station 01DKA-019). Photo numbers (e.g., "19-20") refer to outcrop number. Labeled dots indicate stratigraphic levels of bed samples (e.g., "M" indicates location of sample 01DKA019M). Dashed pattern indicates shale, solid lines indicate non-shale hard beds (either limestone, siltstone or sandstone).

Shale-dominated intervals in OGS-01-01 range up to approximately 3 m in thickness, whereas, interbedded intervals (up to 35% non-shale or hard bed content) range up to 6 m thick. Most hard beds are tabular-bedded, horizontally to sub-horizontally laminated, fine- to medium-grained, calcareous siltstone to fine-grained sandstone (calcisiltites and fine-grained calcarenites) and range up to 33 cm thick, but average less than 10 cm thick. The interbedded units also contain minor, grey, medium- to coarse-grained, bioclastic limestone beds, up to 10 cm thick. The thickest and most abundant hard beds occur in the lowest unit, unit 10, from a depth of 28.22 to 32.00 m. Carbonate content is relatively low in drill hole OGS-01-01, however, there is an unusually high amount of sulphur in the topmost unit (Figure 10).

Although the middle part of the Georgian Bay Formation's outcrop belt is covered by extensive Quaternary deposits, small areas of thin drift have been identified near Rosemont, west of Alliston. Part of this area was mapped as Queenston Formation, however, drilling by the OGS (drill hole OGS-89-06; Rutka and Vos 1993) determined that the Georgian Bay Formation is the youngest bedrock unit at that location. Two outcrops of the Georgian Bay Formation in this area were investigated in 2001. Another hole, OGS-01-02, was drilled approximately 1.5 km east of OGS-89-06, on the east side of Concession 4 Road, Adjala Township, approximately 1.5 km south of Highway 89.

Drill hole OGS-01-02 encountered 2.25 m of overburden, and was completed to a depth of 37.72 m. The lithologic log for this hole is presented in Table 6-3 of Appendix 6 and geochemical data is presented in Table 6-9 in Appendix 6. The Georgian Bay Formation in this hole was subdivided into 8 units based primarily on relative abundance of hard beds (or non-shale) and shale (Figure 8). Shale-dominated units range up to 5.76 m in thickness and interbedded units range up to 5.31 m. Hard beds in shale-dominated units are commonly less than 5 cm thick, whereas those in the interbedded units average 10 cm in thickness and range up to 35 cm thick. The thickest beds occur in the thickest interbedded unit, unit 4, from 17.16 to 22.47 m deep.

A comparison of plots in Figures 10 and 11, shows that the Georgian Bay Formation strata intersected in OGS-01-02 is slightly more calcareous than that in OGS-01-01 and contains significantly more sulphur. Drill hole OGS-01-02 contains a weighted average (weighting method explained in "Composite Sample" section of "Geochemical Results" chapter) of 0.23% sulphur, as compared to 0.05% for OGS-01-01 (Table 14). Drill hole OGS-89-06, contains less sulphur (weighted average of 0.12%) and slightly more carbonate than the stratigraphically lower OGS-01-02 (Table 14).

In the northern part of its outcrop belt, large sections of the Georgian Bay Formation are exposed along rivers and creeks and in bluffs along the Georgian Bay shoreline. Three major sections were examined: the Southeast Claybanks (station 01DKA-018), East Meaford Creek (station 01DKA-019) and Sucker Creek (station 01DKA-022). In addition, 2 holes drilled in 2001 intersected part of the Georgian Bay Formation: holes OGS-01-04 (station 01DKA-033) located southeast of Meaford and OGS-01-05 (station 01DKA-034), located northwest of Meaford (Table 2).

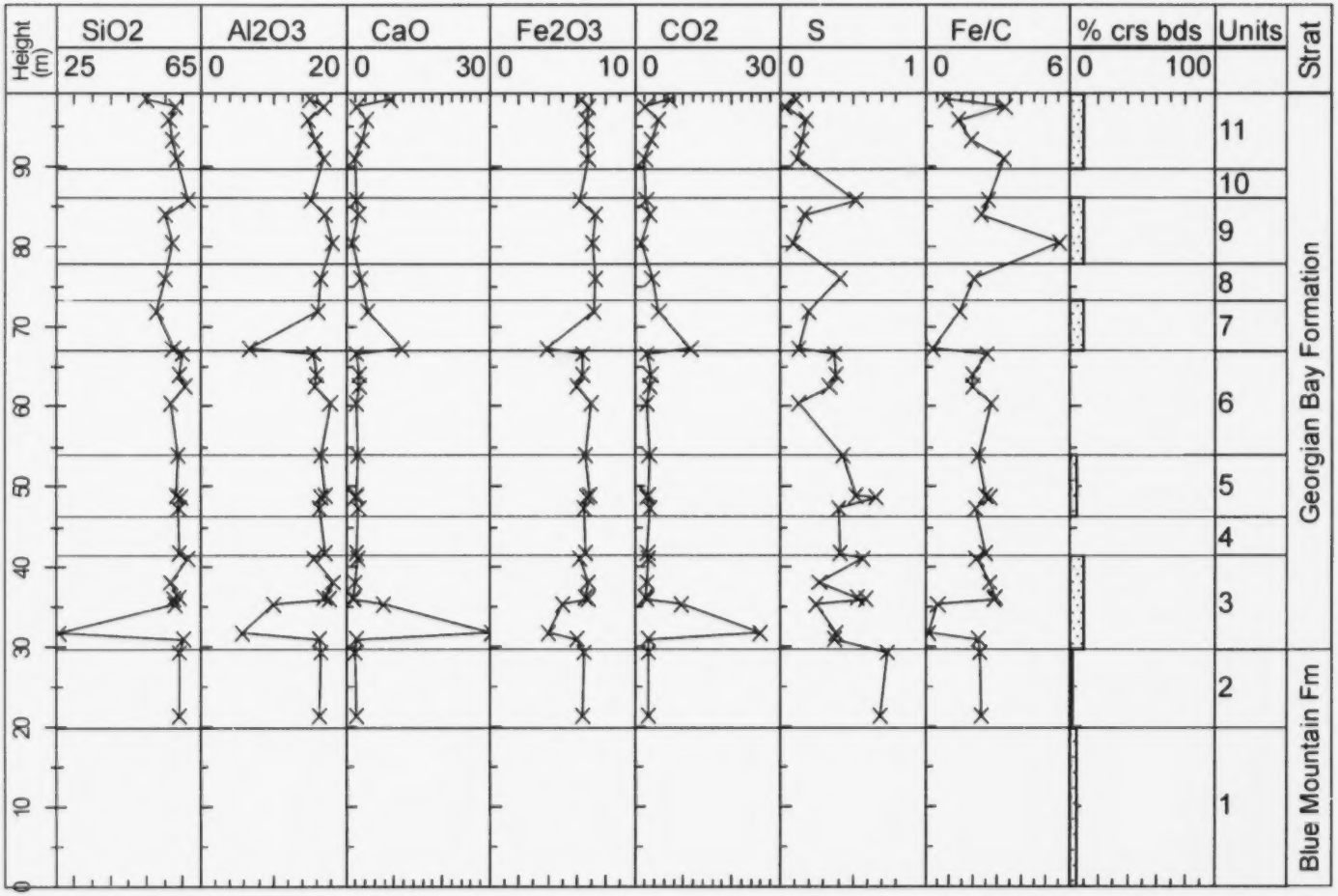

Figure 9: Plot of selected element oxide contents (in weight %) in bed samples from the East Meaford Creek section (station 01DKA-019). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units; "Strat" = bedrock stratigraphy. Sample information is presented in Appendix 3 and the complete geochemical data set in Appendix 5.

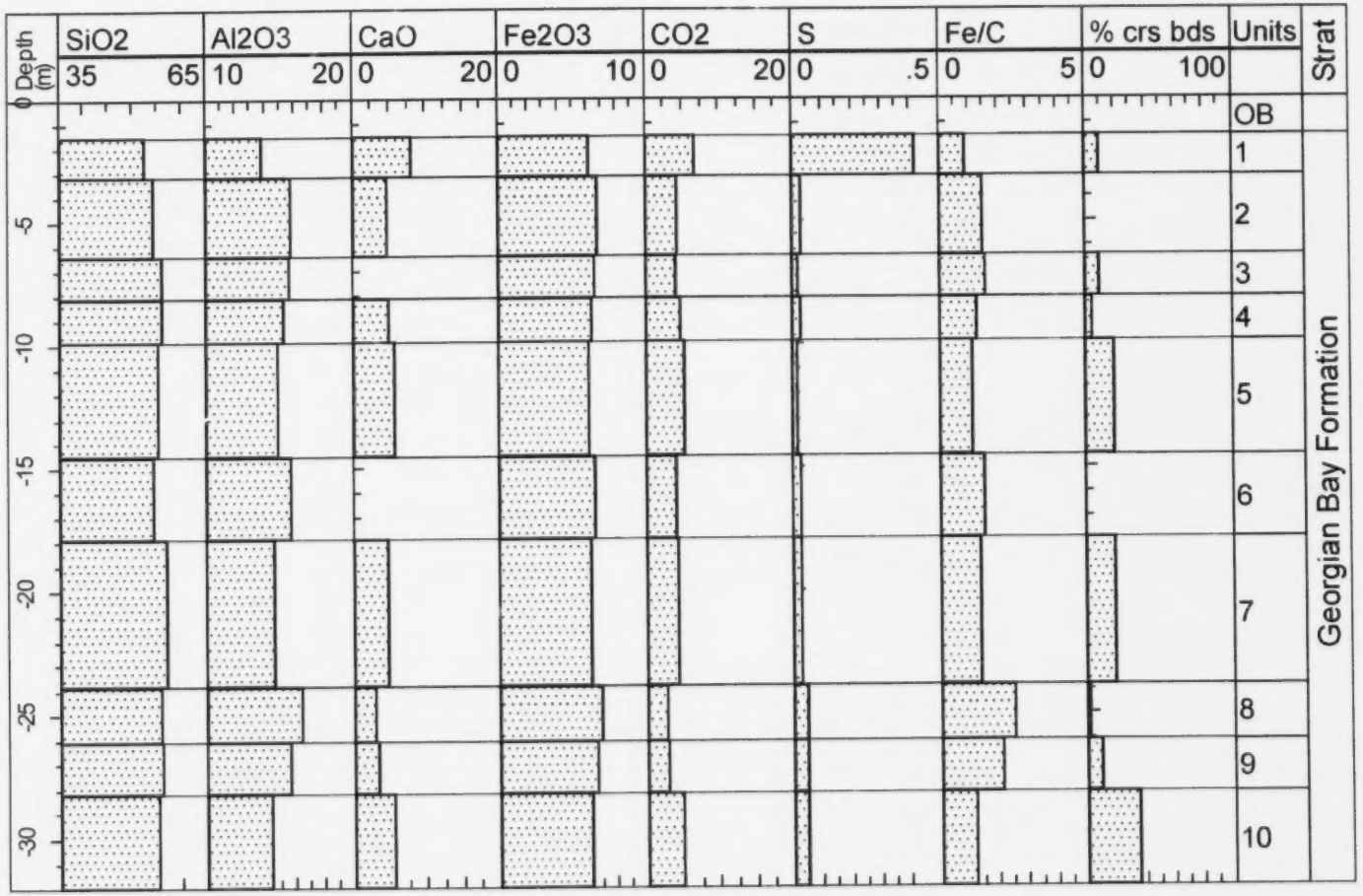

Figure 10: Plot of selected element oxide contents (in weight %) in composite samples from drill hole OGS-01-01 (station 01DKA-30). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units;"OB" = overburden; "Strat" = bedrock stratigraphy. Sample information and geochemical data are presented in Appendix 6.

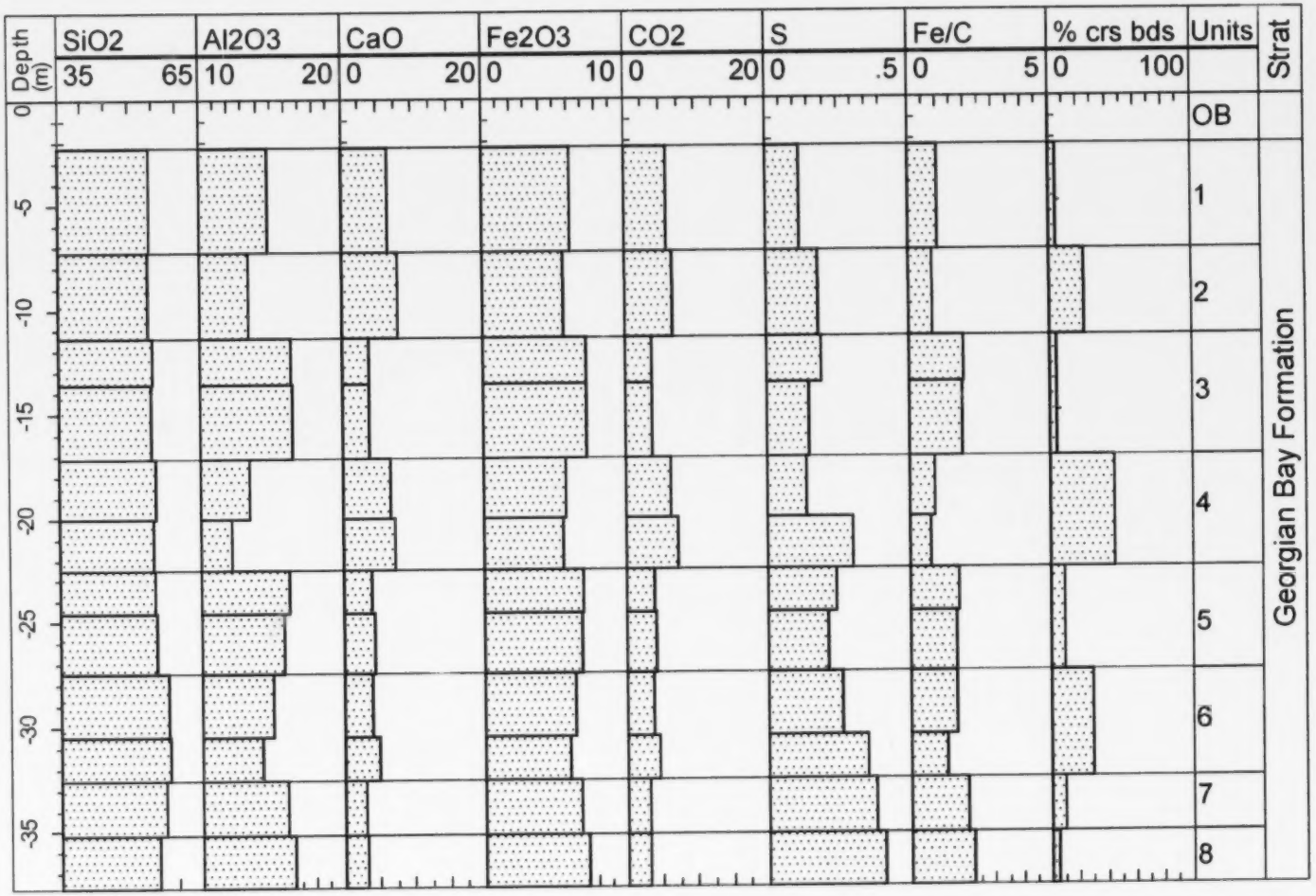

Figure 11: Plot of selected element oxide contents (in weight %) in composite samples from drill hole OGS-01-02 (station 01DKA-031). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units; "Strat" = bedrock stratigraphy. Sample information and geochemical data are presented in Appendix 6.

Table 14: Geochemistry of formational intervals in OGS drill holes from 2001, 2000 and 1989 drilling programs. Values are weighted averages (weighting method explained in "Composite Sample" section of "Geochemical Results" section) of composite samples, except for * holes, which are averages of bed samples. Complete geochemical data sets are presented in Appendix 6 and in Armstrong (2001b).

Formation	Drill Hole #	Thickness (m)	SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
Queenston Formation	OGS-01-04	13.82	44.98	11.93	3.58	13.72	5.28	11.44	0.03	0.48
	OGS-01-05	2.09	42.17	10.32	6.92	12.95	4.41	15.58	0.17	0.28
	OGS-01-06*	22.95	56.60	14.48	2.98	5.92	6.26	4.83	0.02	2.01
	OGS-00-A1	30.93	47.62	11.71	2.76	12.79	4.96	10.46	0.05	0.47
	OGS-00-A2	30.60	51.46	12.66	2.80	9.94	5.22	8.35	0.02	0.63
	OGS-00-A4	31.02	48.80	12.04	2.76	12.00	4.95	9.87	0.06	0.50
	OGS-00-A6	31.01	44.48	11.55	2.84	14.52	4.72	12.26	0.17	0.39
	OGS-00-A8	15.42	48.19	13.18	3.24	10.79	5.33	9.22	0.07	0.58
	OGS-00-A10	9.41	42.22	10.75	2.77	17.10	4.69	14.32	0.03	0.33
	OGS-00-B1	46.76	42.44	12.52	3.52	14.06	5.30	12.23	0.09	0.43
	OGS-00-B4	13.01	48.37	12.63	3.26	11.30	5.35	9.79	0.01	0.55
	OGS-00-C1*	69.49	39.04	11.97	4.62	14.62	5.27	13.70	0.46	0.39
	OGS-00-C2	48.94	36.83	11.93	5.29	16.04	5.23	15.92	0.17	0.33
	OGS-89-09	35.96	56.64	14.78	2.59	4.64	6.37	3.21	0.29	2.04
	OGS-89-08	25.91	52.19	13.12	2.76	8.36	5.78	6.85	0.04	0.97
	OGS-89-05a	44.19	48.72	12.30	2.43	10.91	5.35	8.68	0.30	0.69
	OGS-89-10	11.88	53.21	13.62	2.69	7.46	6.39	6.48	0.04	1.73
Georgian Bay Formation	OGS-01-01	30.50	55.43	15.18	3.33	4.94	6.46	4.57	0.05	1.49
	OGS-01-02	35.47	55.49	14.99	3.32	5.26	6.50	4.92	0.23	1.45
	OGS-01-04	47.26	50.62	13.40	3.37	9.55	5.59	8.27	0.19	0.88
	OGS-01-05	56.59	51.53	13.42	4.19	7.92	5.58	8.19	0.21	0.90
	OGS-01-06*	38.01	47.61	11.94	3.17	12.97	5.35	11.58	0.51	0.99
	OGS-00-B4	5.66	45.47	10.37	3.94	14.33	4.42	13.66	0.15	0.33
	OGS-89-10	10.98	50.18	12.96	3.66	8.45	5.38	8.86	0.50	0.61
	OGS-89-06	27.12	53.28	14.72	3.66	5.28	6.16	5.50	0.12	1.55
Blue Mountain Fm	OGS-01-03	42.52	56.13	16.56	3.37	3.06	6.81	3.69	0.74	1.87

A composite section for East Meaford Creek and vertical geochemistry plots for both the Southeast Claybanks and East Meaford Creek are presented in Figures 7, 8 and 9. In the East Meaford Creek section, the Georgian Bay Formation was measured from a height of 29.65 m above lake level to over 98.70 m; stratigraphically higher outcrops, located further upstream, were not examined for this study. The total measured section of approximately 69 m, was subdivided into 11 units based on relative abundance of shale and non-shale components. Shale-dominated (<10% non-shale beds) units range up to 13 m in thickness and interbedded units (up to 10% non-shale beds) range up to 9 m thick. Thinner, metre-scale packages with higher proportions of non-shale components occur locally in the interbedded units.

In the Southeast Claybanks section (01DKA-018), the Georgian Bay Formation forms the top 10.25 m of the bluff (Figure 7). Shale-dominated units range up to 5 m in thickness, and interbedded units, with up to 50% non-shale beds, range up to 1.25 m thick. Units 5 through 7 in this section correlate relatively well with the lower part of unit 3 in the East Meaford Creek section (Figures 8 and 9).

A composite section for Sucker Creek (Figures 12 and 13), located northwest of Meaford, in the northwest corner of the Canada Forces Training Centre Meaford, was constructed from a series of 20 individual outcrops along the creek from the shore of Georgian Bay, southward to just north of Hogs Back Road. The Sucker Creek section, totaling 38.65 m, was subdivided into 7 units based on the relative abundance of shale and non-shale components. Shale-dominated units range to greater than 12 m in thickness and interbedded units range up to 7.7 m thick. Non-shale components (i.e., hard beds), consist mainly of tabular bedded, horizontally to sub-horizontally laminated, grey, fine-grained calcisiltite to calcarenite (or calcareous siltstone to sandstone). Locally, beds have fossiliferous lags and rippled tops. They commonly pinch out laterally and locally are lensy. Some hard beds consist of medium- to coarse-grained, bioclastic limestone. Hard beds in the Sucker Creek section, range up to 20 cm in thickness, but are more commonly 5 to 10 cm thick.

Drill hole OGS-01-04 (station 01DKA-033), collared in the lower Queenston Formation, encountered the Georgian Bay Formation at a depth of 13.82 m and cored a further 47.26 m of the Georgian Bay Formation (Figure 14). Drill hole OGS-01-05 (station 01DKA-034) encountered 56.59 m of Georgian Bay Formation strata beneath 2.09 m of Queenston Formation strata and 2.59 m of Quaternary overburden (Figure 15). In both of these cores, the top 7 to 10 m of the Georgian Bay Formation is generally more calcareous than the underlying parts of the formation. Also, the alternating shale-dominated and interbedded packages characteristic of the lower part of the formation are not well developed in this interval. Fossiliferous, bioclastic limestone beds are also more prevalent in this upper part of the formation. These characteristics are consistent with the informal upper member of the Georgian Bay Formation as defined by Liberty (1969). In the lower part of the formation, in these 2 drill holes, shale-dominated units range up to 6.7 m thick, but commonly are less than 4 m thick. Interbedded or hard bed-dominated units in the lower part of the formation are commonly no more than 3 m thick.

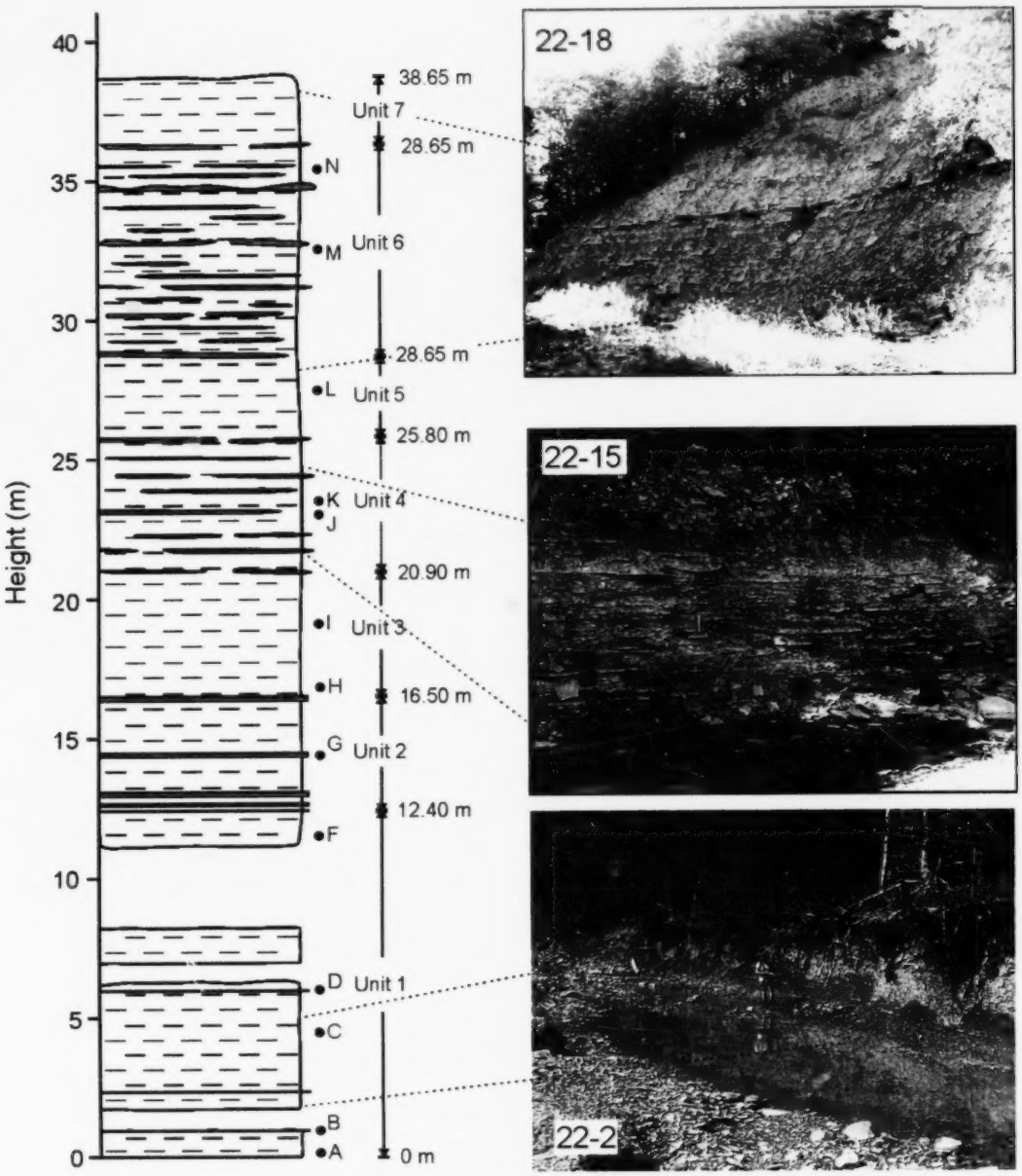

Figure 12: Composite section of the Georgian Bay Formation from 20 outcrops along Sucker Creek (station 01DKA-022), northwest of Meaford. Photo numbers (e.g., "22-15") refer to outcrop number. Labeled dots indicate stratigraphic levels of bed samples (e.g., "M" indicates location of sample 01DKA022M). Dashed pattern indicates shale, solid lines indicate non-shale hard beds (either limestone, siltstone or sandstone).

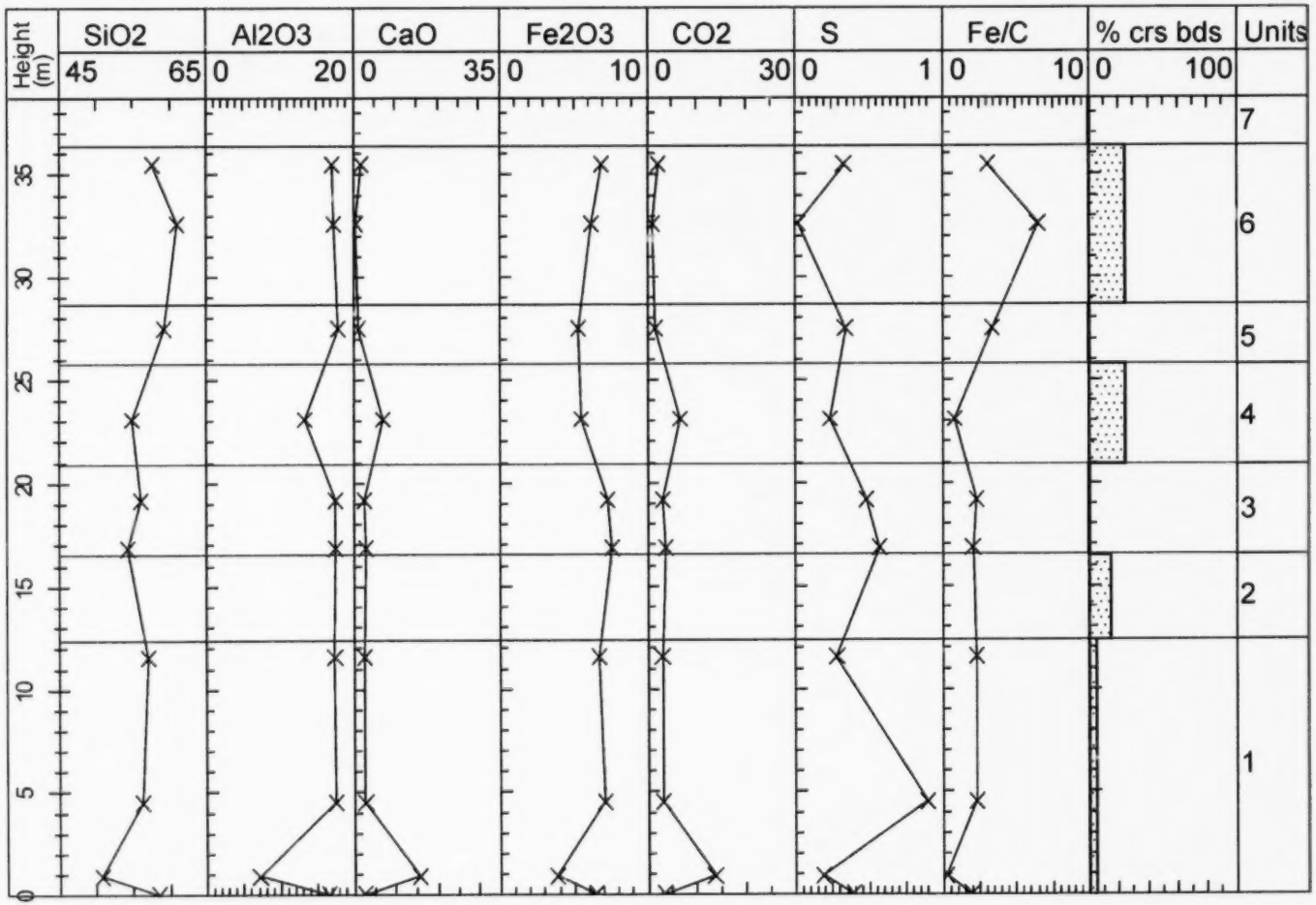

Figure 13: Plot of selected element oxide contents (in weight %) in bed samples from the Sucker Creek section (station 01DKA-022). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units. Sample information is presented in Appendix 3 and the complete geochemical data set in Appendix 5.

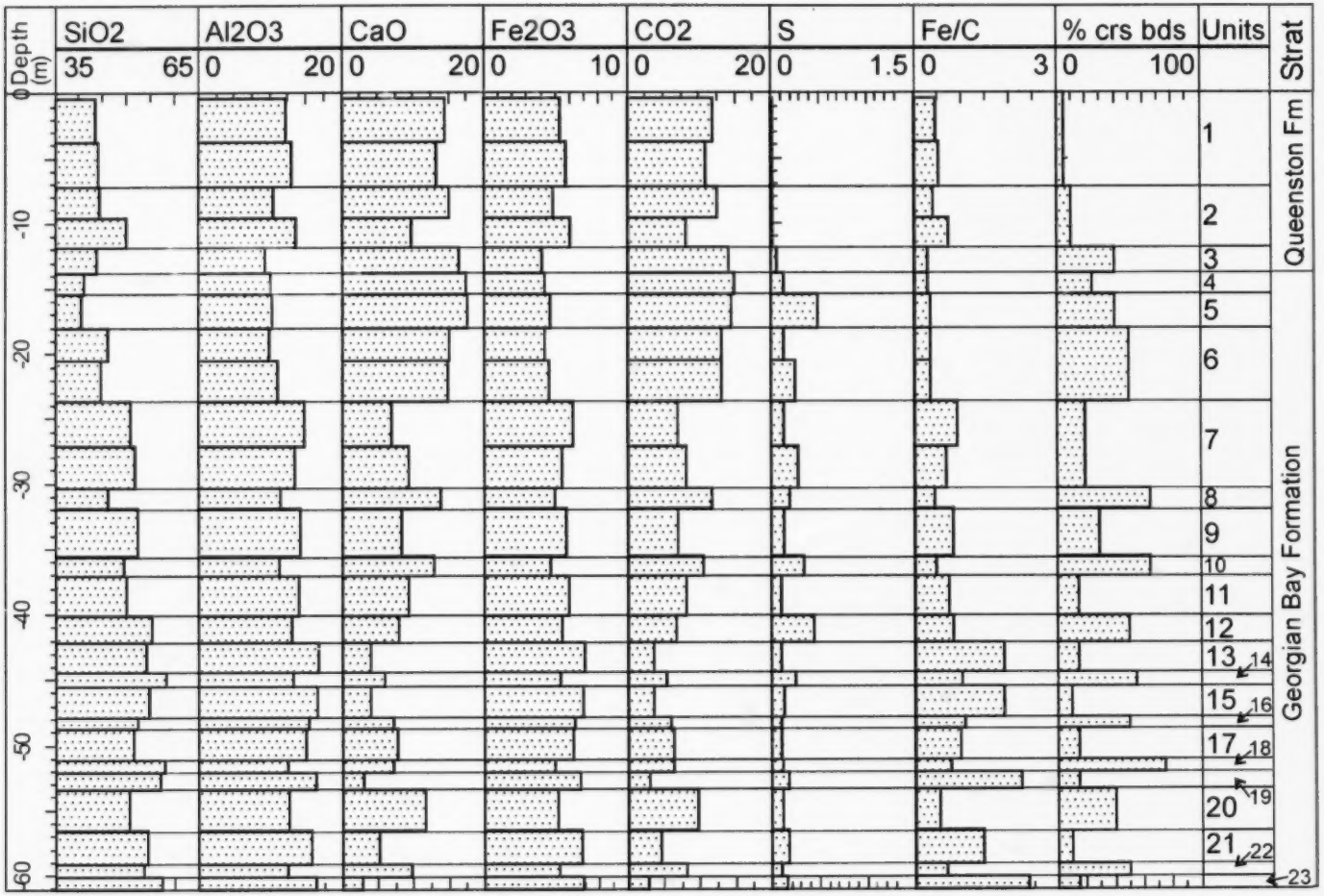

Figure 14: Plot of selected element oxide contents (in weight %) in composite samples from drill hole OGS-01-04 (station 01DKA-033). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units; "Strat" = bedrock stratigraphy. Sample information and geochemical data are presented in Appendix 6.

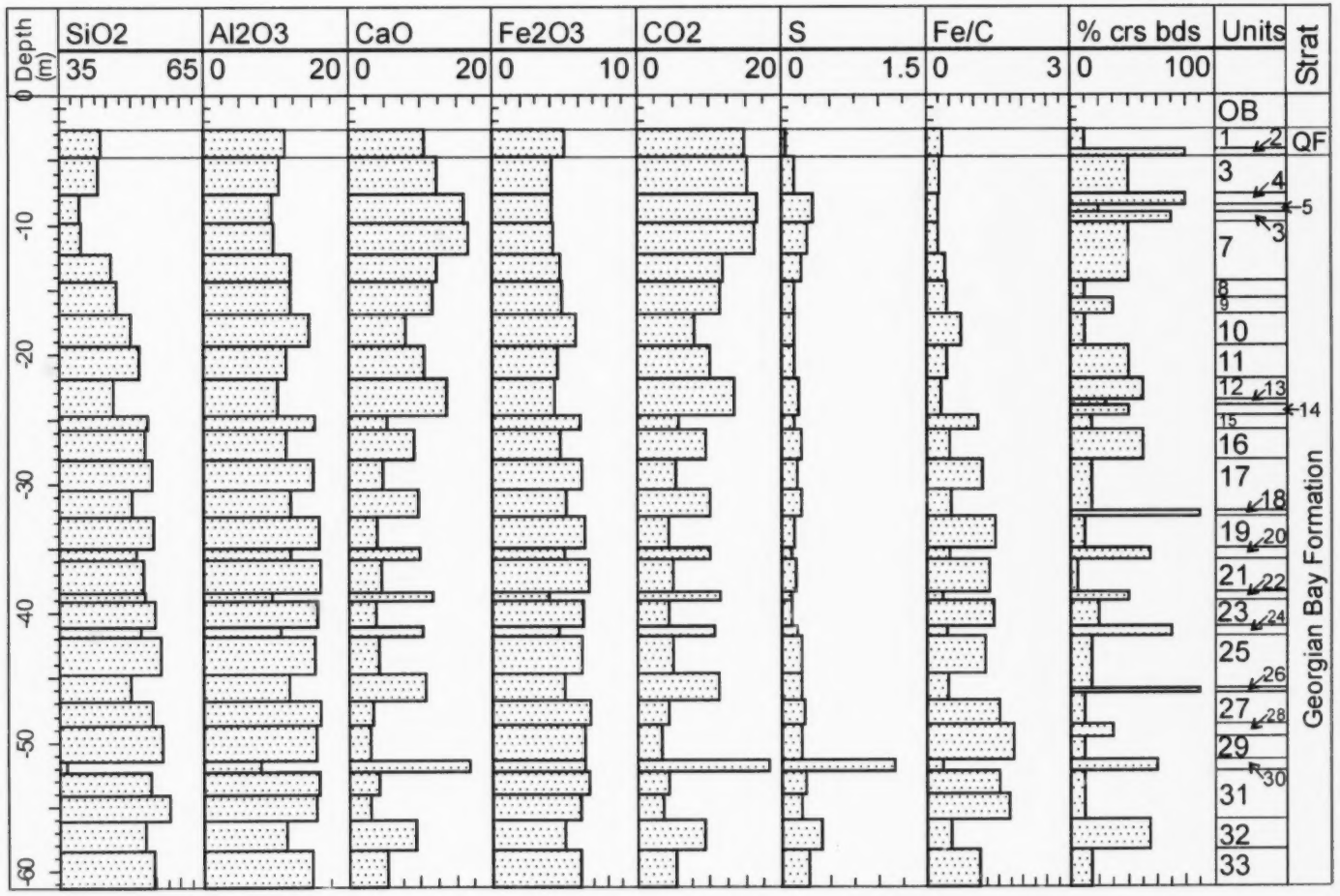

Figure 15: Plot of selected element oxide contents (in weight %) in composite samples from drill hole OGS-01-05 (station 01DKA-034). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units; "Strat" = bedrock stratigraphy; "QF" = Queenston Formation. Sample information and geochemical data are presented in Appendix 6.

In Eastern Ontario, the Carlsbad Formation is considered to be equivalent to the Georgian Bay Formation (Table 1; Williams 1991; Williams and Telford 1986). Outcrops of the Carlsbad Formation are sparse (Williams, Rae and Wolf 1985a) and none were examined in this study. Investigation of the Carlsbad Formation was conducted using 2 drill cores, the Geological Survey of Canada's Russell County well (Williams 1991) and a new core, OGS-01-06 (Table 2) drilled at the Russell Quarry as part of this study. In the GSC core, Williams (1991) assigned 186.9 m of strata to the Carlsbad Formation, whereas, Kerr and Eyles (1991) assigned 259 m to this formation. The difference is likely due to the very gradational nature of the formation's basal contact with the underlying Billings Formation.

Drill hole OGS-01-06 (Figure 16) encountered an incomplete interval, 38.01 m thick, of the Carlsbad Formation beginning at a depth of 22.95 m. The top 13.24 m of the formation in this core is more calcareous and generally has a higher proportion of coarse beds (Figure 16) than the remainder of the Carlsbad Formation in this hole. This interval may be correlative with the upper member of the Georgian Bay Formation of Liberty (1969) and may represent strata previously assigned to the Russell Formation by Wilson (1964).

Two relatively small areas of thin drift over the Carlsbad Formation are identified outside of urban Ottawa, near Russell and Vars (Figures 1b (back pocket) and 3).

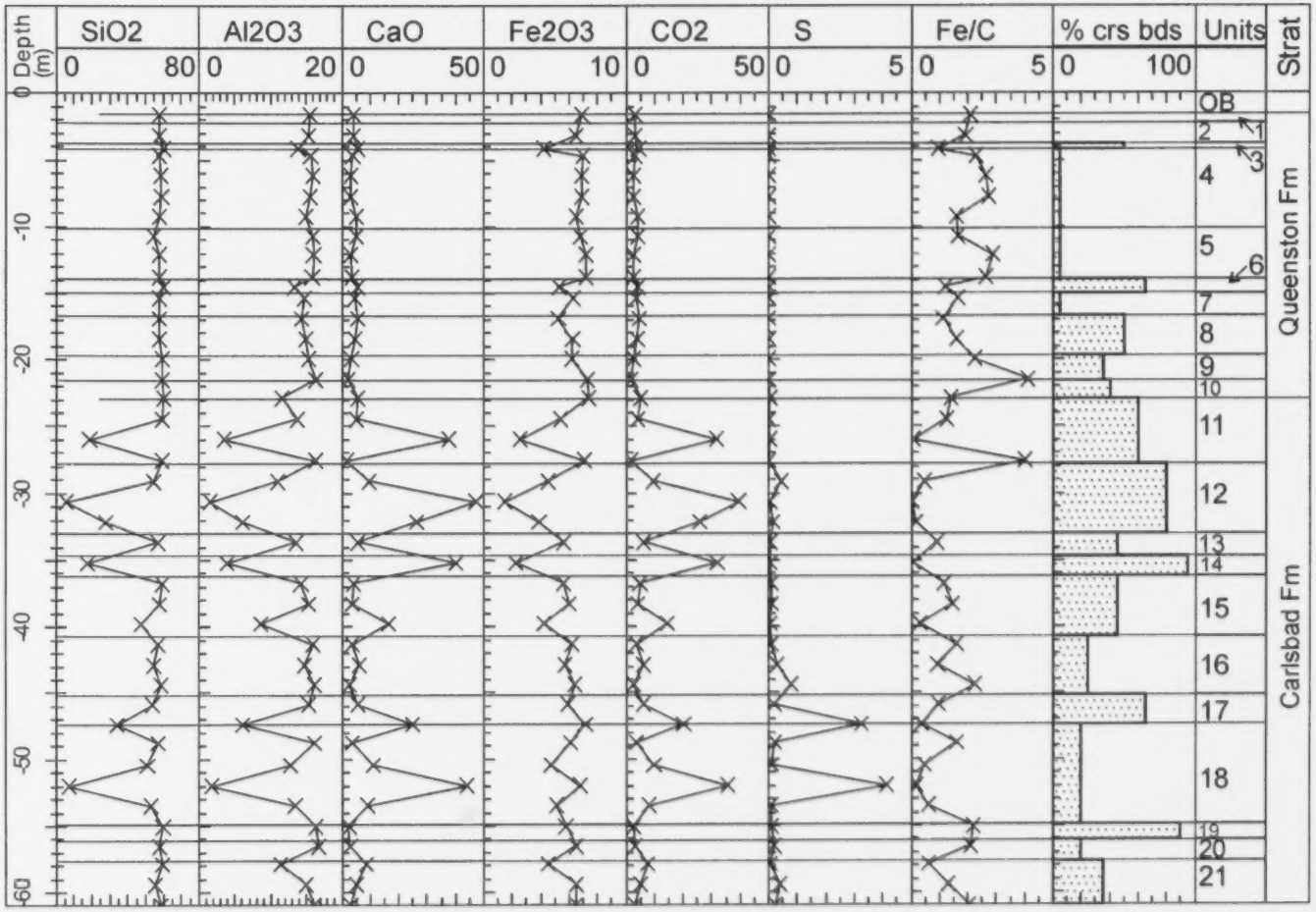

Figure 16: Plot of selected element oxide contents (in weight %) in bed samples from drill hole OGS-01-06 (station 01DKA-035). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-shale components within a unit; "Units" = local lithologic units; "Strat" = bedrock stratigraphy. Sample information and geochemical data are presented in Appendix 6.

QUEENSTON FORMATION

The shale resources of the Queenston Formation were the focus of the first phase of this study (Armstrong 2001b). In 2001, additional field data was acquired both along the main outcrop belt and in eastern Ontario. Field mapping stations along the main outcrop belt included: the Burnstein Quarry (01DKA-010) near St. Davids, at the eastern end of the Niagara Peninsula; the former Hamilton Brick Quarry and now the site of the Century Brick Limited brick plant (01DKA-009); 3 large outcrops northwest of Mansfield (01DKA-014, -015 and -016); the Lavender Badlands, south of Creemore (01DKA-017); and a number of small outcrops in the area south of Thornbury and south and northwest of Meaford (listed in Appendix 1). A core drilled in 1980 by the OGS at the inactive Duntroon Quarry, south of Collingwood, was also logged and sampled (station 01DKA-011). In eastern Ontario, the Russell Quarry (01DKA-020) was studied, as were the GSC Russell well (01DKA-021) and a new hole, OGS-01-06, drilled for this study (station 01DKA-034). The geochemistry of the Queenston Formation for the aforementioned stations is summarized in Table 15.

Table 15: Average content (in weight %) of selected elements for 2001 Queenston Formation field mapping stations. All values are averaged bed samples, except for values for "*" locations, which are weighted averages (method explained in "Composite Sample" section of "Geochemical Results" section) of composite samples. Station locations are listed in Appendix 1. Complete geochemical data sets are in Appendices 4 and 5. "n" = number of samples.

Location (station #)	n	SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	CO_2	S	Fe_2O_3/CO_2
Burnstein Quarry (01DKA-010)*	1*	58.65	15.02	2.77	3.72	6.11	3.01	n.d.	2.03
Burnstein Quarry (01DKA-010)	4	58.10	14.75	2.83	4.98	5.75	4.11	0.01	1.64
Century Brick plant - Hamilton Quarry (01DKA-009)	6	52.32	14.53	3.02	7.98	6.11	6.36	0.01	1.27
Mansfield road cut (01DKA-014)	8	51.52	13.02	2.81	9.73	5.96	7.58	0.01	0.96
Perm road cut (01DKA-016)	9	40.14	11.09	3.17	17.70	4.70	14.42	0.02	0.36
Whitfield road cut (01DKA-015)	7	45.73	13.52	3.10	12.42	5.86	9.90	0.01	0.79
Lavender road cut (01DKA-017)	7	45.52	14.00	3.49	12.04	5.45	10.12	0.01	0.55
Duntroon core (01DKA-111)*	53*	42.27	12.49	4.08	13.98	5.30	12.43	0.34	0.46
Loree (01DKA-025)	5	37.81	11.40	2.81	18.79	5.03	14.16	0.02	0.41
Silcote (01DKA-026 & -027)	7	38.29	11.69	6.42	14.57	5.04	14.74	0.02	0.36
south Meaford (0DKA-028 & -029)	8	39.21	11.84	5.21	15.43	5.07	14.07	0.02	0.47
Russell Quarry (01DKA-020)*	6*	59.53	15.41	2.77	3.67	6.53	2.97	0.01	2.44

At the east end of the Niagara Peninsula, one area of thin drift exists. This area is located northwest of St. Davids, southeast of Niagara-on-the-Lake, and is centred on the Burnstein Quarry (Figures 1a (back pocket) and 2). This presently inactive quarry, owned by Canada Brick, was formerly operated by the St. Catharines Brick and Tile Company Limited (Guillet 1967). At the time of examination, the quarry was partly filled with water and only the top, approximately 1.5 m of section, was exposed. This section consists of red shale with minor thin, green calcareous siltstone beds. Bed samples, obtained from the section, and a composite sample from the stockpile (Appendixes 4 and 5) indicate the shale here to be at the low end of the range of carbonate content for the Queenston Formation (cf. values in Table 15 with Table 3 (this report) and Tables 2 and 7 *in* Armstrong 2001b). Gypsum nodules or lenses were not observed within the exposed strata at this quarry.

A large outcrop on the property of the Century Brick Limited brick plant in Hamilton (01DKA-009) exposes approximately 24 m of the upper Queenston Formation. The section was subdivided into 3 units: a 10 m thick basal unit, consisting of red shale with interbeds of green siltstone and shale up to 35 cm thick, spaced approximately 1 to 2 m apart; a middle unit, 18.7 m thick, consisting of red shale with sparse thin green beds; and an upper unit approximately 5 m thick, consisting of red shale with green beds up to 15 cm thick, typically spaced 1.5 m apart (the basal 0.5 m of this unit consists of a package of 3 green beds). The carbonate content of this section, as indicated from the average CO_2 content (Table 15), is below the average for the Queenston Formation (cf. Table 3 (this report) and Tables 2 and 7 *in* Armstrong 2001b). Gypsum was not observed in this outcrop.

The largest area of thin drift over the Queenston Formation is in the area between Mississauga, Hamilton and Milton (Figures 1a (back pocket) and 2). This area, host for numerous past and present shale quarries and brick plants, is currently undergoing widespread urbanization. Quarries, outcrops and recent drill holes studied by Armstrong (2001b) provide a relatively complete cross-section through the Queenston Formation in this area.

A few relatively large areas of thin drift over the Queenston Formation occur in the Georgetown, Brampton and Cheltenham areas (Figures 1a (back pocket) and 2). Outcrop, quarry and recent drilling affords a relatively good section through the formation in this area as well (Armstrong 2001b). The largest of the thin drift areas, located north of Norval and west of Brampton, has been largely zoned for urban expansion. Another relatively large area, a long narrow area along the Niagara Escarpment, lies within the Niagara Escarpment Plan Area (NEPA).

A number of small thin drift areas occur in the central part of the main outcrop belt of the Queenston Formation (Figures 1a (back pocket) and 2). Small scattered areas are located east of Orangeville. A relatively large area, located west of Alliston near Rosemont, was determined to be underlain, at least in part, by the Georgian Bay Formation (Rutka and Vos 1993; Armstrong 2001b). A concentration of small thin drift areas are located northwest of Mansfield. One of these was tested with drill hole OGS-00-B1 (Armstrong

2001b) and 3 large sections in this area were investigated in 2001. These sections included, in approximate stratigraphic order from bottom to top, a road cut adjacent to the Mansfield Ski Resort (station 01DKA-014), a road cut north of Perm (station 01DKA-016) and a large road cut east of Whitfield (station 01DKA-016). The geochemistry of these sections is summarized in Table 15. The Perm road cut is the most calcareous and likely represents the middle of the formation. The Whitfield road cut lies within the NEPA. Gypsum was not observed in any of these outcrops. The Mansfield road cut section is schematically illustrated in Figure 17. A vertical plot of selected element content and percentage coarse or green beds versus height is presented in Figure 18.

A large outcrop (station 01DKA-017) of the upper Queenston Formation is located east of Lavender in an area of thin drift south of Creemore (Figures 1a (back pocket) and 2). Although this area lies within the NEPA, this outcrop provides a regional reference point for the formation. This outcrop, informally called the Lavender Badlands, exposes 21.65 m of mainly red shale, with minor thin, green beds (calcisiltite and shale), green shale mottles and green sub-vertical fractures. The topmost 1.80 m of this outcrop consists almost entirely of green shale, and likely represents the top of the formation. Although the upper contact with the overlying Whirlpool Formation was not observed, it is reported for this locality (A.P. Hamblin, Geological Survey of Canada, personal communication, 2001) and slabs of the Whirlpool and overlying Manitoulin formations are abundant near the top of the outcrop. Geochemically, this outcrop is similar to the Whitfield outcrop (Table 15).

Between Creemore and Collingwood, an area of thin drift occurs west of Duntroon. Part of this area lies within the NEPA (Figure 1a (back pocket)). At the immediate western edge of the thin drift area the inactive Duntroon Quarry exposes the overlying Whirlpool and Manitoulin formations. In 1980, the OGS drilled a hole, called OGS-80-1, from the floor of this quarry. This core is presently stored at the Oil, Gas and Salt Resources Library in London, Ontario. In descending order, OGS-80-1 encountered 1.55 m of the Whirlpool Formation, 88.75 m of the Queenston Formation and 1.80 m of the Georgian Bay Formation (Figure 19). Chip samples were obtained at regularly spaced intervals and combined, based on lithologically defined units, into composite samples. Gaps between units and composite samples are due to gaps in the core (some intervals have been completely sampled). A plot of selected element content and units versus depth for OGS-80-1 are presented in Figure 19. The CO_2 content of the Queenston Formation in this core is generally between 10 and 15%, averaging 12.03% (Table 15), suggesting that much of formation at this location would be suitable for producing buff-yellow bricks.

Thin drift areas over the Queenston Formation also occur south and southeast of Thornbury (Figures 1a (back pocket) and 2). No outcrops were found in the area south of Thornbury. In the area southeast of Thornbury, an outcrop east of Ravena, near Loree, was examined and sampled (station 01DKA-025). This outcrop, actually 2 adjacent roadside outcrops separated by a 9 m covered interval, consists mainly of red shale and represents a total stratigraphic interval of 21.50 m of the upper Queenston Formation. Average content of selected elements in this outcrop is presented in Table 15. The thin drift area southeast of Thornbury lies almost entirely within the NEPA.

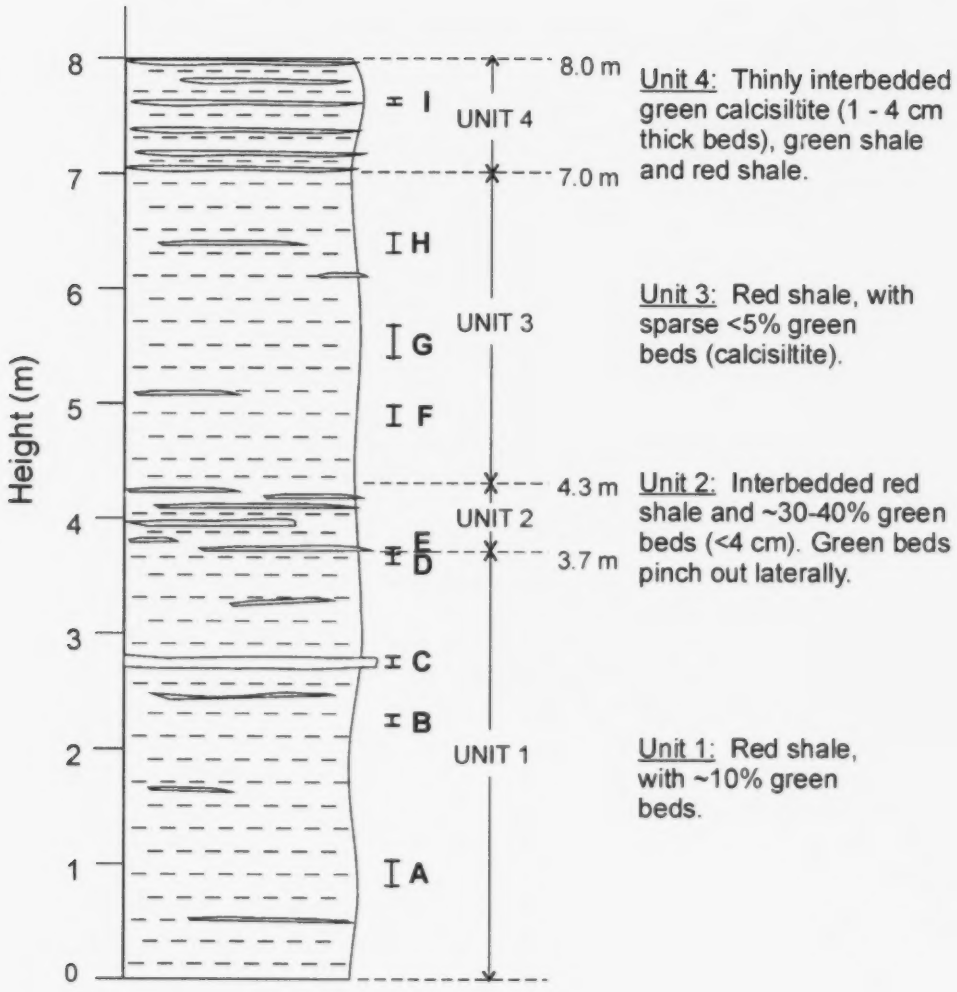

Figure 17: Composite section and unit descriptions for the Queenston Formation exposed in the Mansfield Ski Hill road cut (station 01DKA-014). Labeled bars indicate stratigraphic location and interval of bed samples (e.g., "H" indicates location of sample 01DKA014H). Dashed pattern indicates shale, solid lines indicate non-shale hard beds (either siltstone or sandstone).

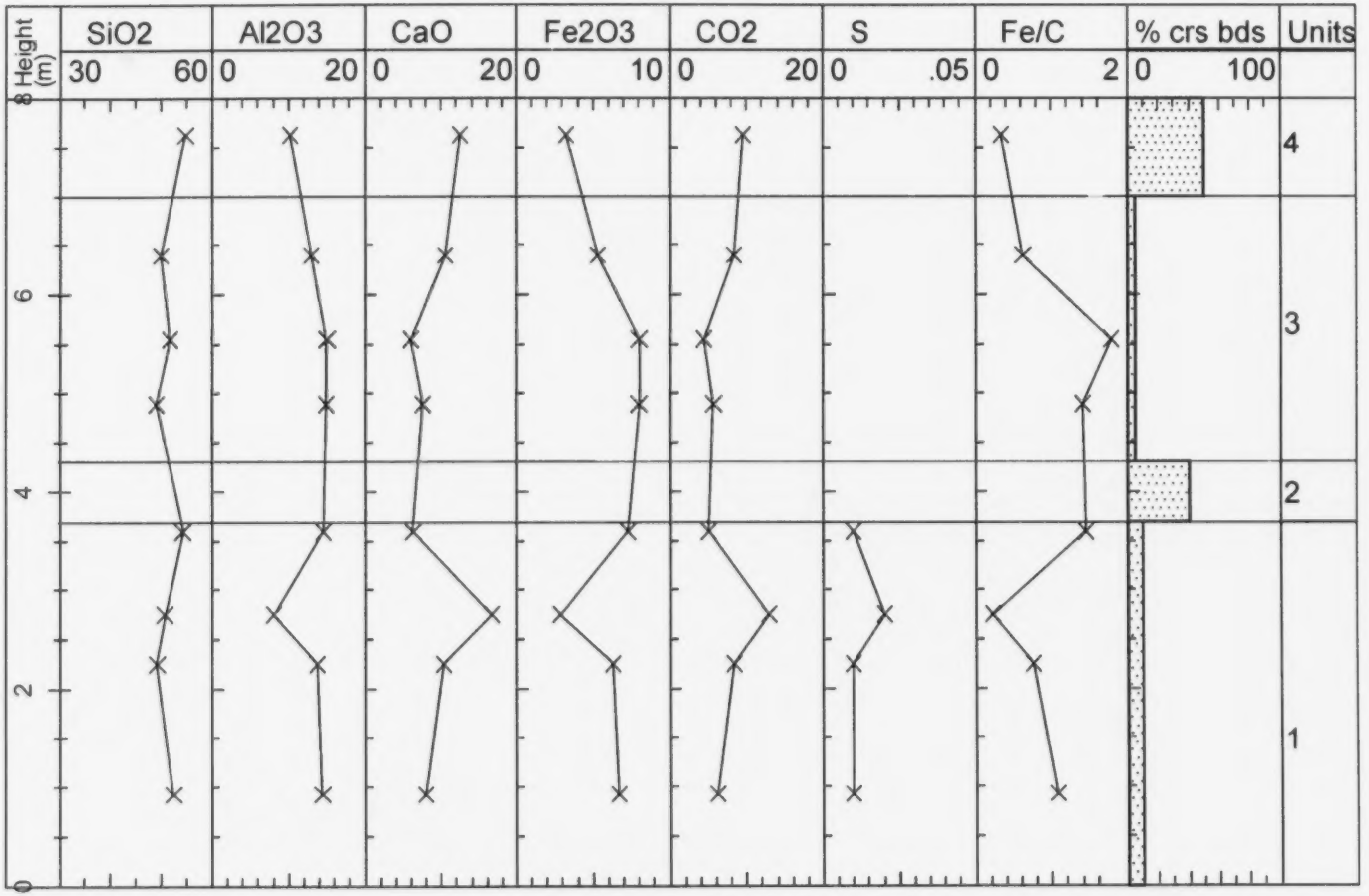

Figure 18: Plot of selected element oxide contents (in weight %) in bed samples from the Mansfield Ski Hill road cut (station 01DKA-014). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-red shale components within a unit; "Units" = local lithologic units. Sample information is presented in Appendix 3 and the complete geochemical data set in Appendix 5.

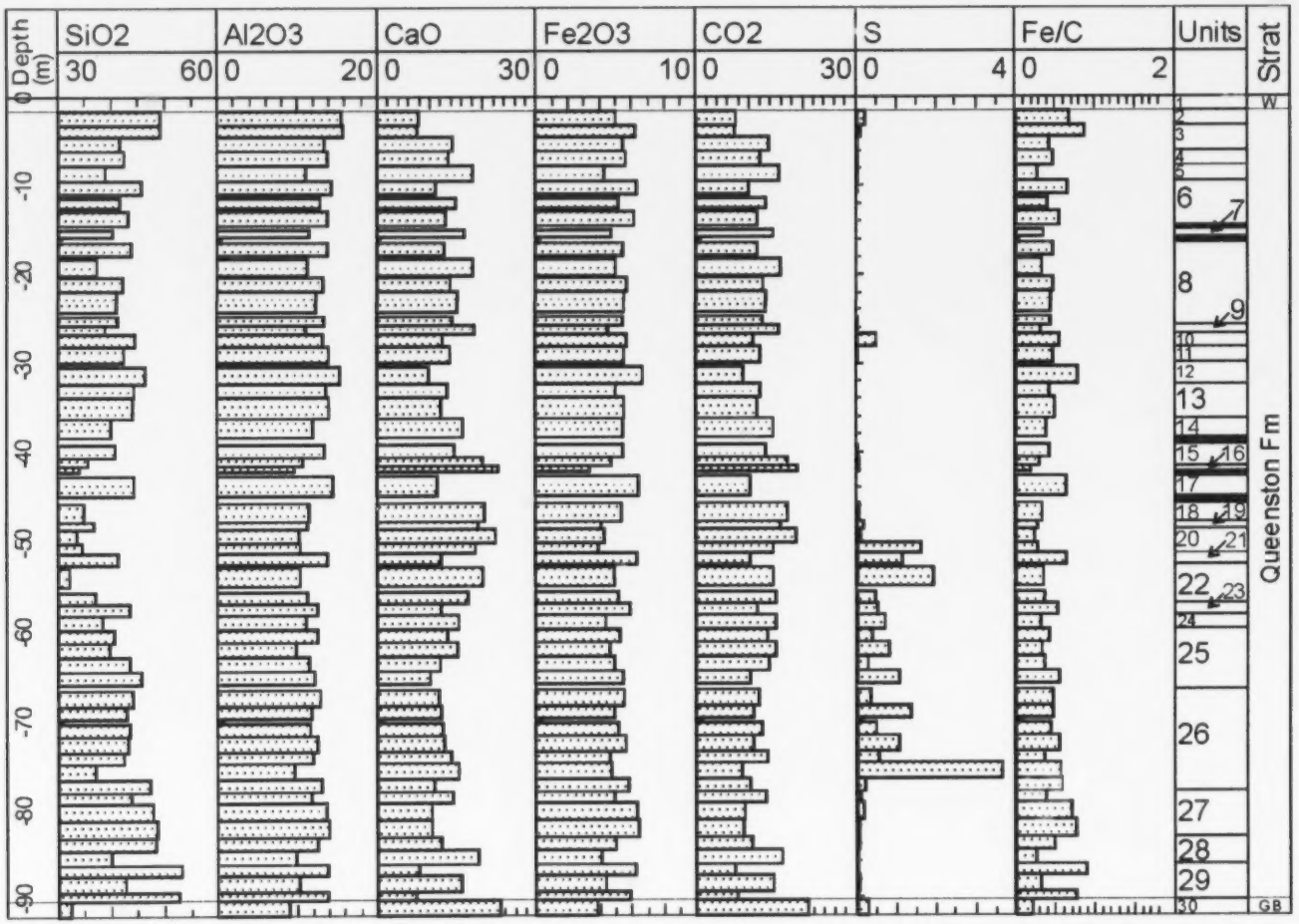

Figure 19: Plot of selected element oxide contents (in weight %) in composite samples from the Duntroon Quarry core OGS-80-1 (station 01DKA-011). "Fe/C" = Fe2O3/CO2; "Units" = local lithologic units (black gaps between units are gaps in core record); "GB" = Georgian Bay Fm; "W" = Whirlpool Fm. Sample information is presented in Appendix 2 and the complete geochemical data set in Appendix 4.

A relatively large area of thin drift over the Queenston Formation is located south of Meaford (Figures 1a (back pocket) and 2). Three small outcrops were examined in this area in 2000 and one hole, OGS-00-C1, was drilled through the entire Queenston Formation (Armstrong 2001b). Subsequently, bed samples from OGS-00-C1 were analyzed for a large suite of trace elements and these data are presented in Table 6-11 of Appendix 6. In 2001, 2 more outcrops (01DKA-028 and -029) were examined and another hole, OGS-01-04, was drilled from the lower Queenston Formation into the Georgian Bay Formation. Average content of selected major elements for the 2 outcrops is presented in Table 15 and a plot of selected element content versus depth in OGS-01-04 is presented in Figure 14.

The outcrops 01DKA-028 and 01DKA-029 each expose approximately 3 m of mainly red shale which appear to represent a slightly higher stratigraphic level in the Queenston Formation than the interval (i.e., basal 13.82 m) intersected in OGS-01-04. The average CO_2 content of these 2 outcrops is 14.07% (Table 15), whereas the weighted average CO_2 content for the Queenston Formation interval in OGS-01-04 is 11.44% (Table 14). The average CO_2 content for the approximately 20 m thick interval of the upper Queenston Formation exposed at station 00DKA-027 (from data in Appendix 5 *in* Armstrong 2001b) is 14.05%. These values are stratigraphically consistent with the CO_2 content profile for drill hole OGS-00-C1 (Figure 30 *in* Armstrong 2001b).

Northwest of Meaford, and northeast of Owen Sound, there is a large area of thin drift over the Queenston Formation (Figures 1a (back pocket) and 2). The eastern part of this area is covered by the Canada Forces Training Centre Meaford. This thin drift area was investigated with a drill hole, OGS-00-C2, in 2000 (Armstrong 2001b), and in 2001 with drill hole OGS-01-05 and examination of 2 outcrops, stations 01DKA-026 and 01DKA-027, located north of Silcote.

The 2 Silcote outcrops each expose 3.5 m of mainly red shale and are stratigraphically separated by approximately 30 m of covered interval. The lower outcrop, 01DKA-027, appears to be stratigraphically located just above the middle, carbonate-rich part of the Queenston Formation and the upper outcrop appears to be within 10 m of the top of the formation. Drill hole OGS-01-05 (station 01DKA-034) intersected only 2.09 m of the lower part of the Queenston Formation (Figure 15). This interval has unusually high CO_2 content for the lower Queenston (Table 14), however, an elevated MgO content (6.92%) suggests the carbonate mineral is dolomite rather than calcite.

Gypsum was not observed in any of the outcrops examined in the Thornbury, south Meaford or northwest Meaford areas. Gypsum nodules and fracture-fillings occur in the lower part of the formation exposed in an outcrop at Big Bay (station 00DKA-025), north of Owen Sound. Both forms of gypsum occur in the middle and lower parts of the formation in the 3 cores drilled in this area. This distribution is consistent with the stratigraphic distribution of gypsum in the southern part of the Queenston Formation outcrop belt (Armstrong 2001b).

In eastern Ontario, the Queenston Formation is exposed in the Russell Quarry (station 01DKA-020), located approximately 5 km north of the town of Russell (Figure 2 and 3). The quarry is located in the middle of an area of thin drift and is the only known outcrop of the Queenston Formation in eastern Ontario (Williams 1991). The Russell Quarry exposes approximately 13 m of the red silty shale and minor green shaly siltstone and thin sandstone beds. The formation at this location appears siltier and harder, and is less calcareous than in its main outcrop belt. This is reflected in its higher average SiO_2 and lower average CO_2 contents (Table 15).

Although none of the quarry faces are more than 9 m high, progressively more stratigraphic section is exposed towards the north part of the quarry and 2 low angle faults (one in the west face and one in the north), oriented approximately perpendicular to each other, have apparent offsets of approximately 0.5 m each. Bedding dips at a low angle (<10°) to the north and east in the quarry. The stratigraphically lowest bed in the quarry is a rippled calcareous siltstone that is exposed in the floor of the southwest corner of the quarry. The section was subdivided into 6 units (Figure 20): 3 thin (<0.5 m) more calcareous units with green beds, and 3 thick (>2 m) units consisting of massive red silty shale.

In the winter of 2002, drill hole OGS-01-06 (station 01DKA-035), was cored from the top of the east wall of the Russell Quarry to a total depth of 60.97 m. The basal contact of the Queenston Formation with the underlying grey shales and limestones of the Carlsbad Formation was encountered at a depth of 22.95 m, or approximately 10 m below the floor of the quarry. A plot of selected element contents, per cent coarse beds and unit contacts with depth is presented in Figure 16, and the average content of selected major elements is listed in Table 14.

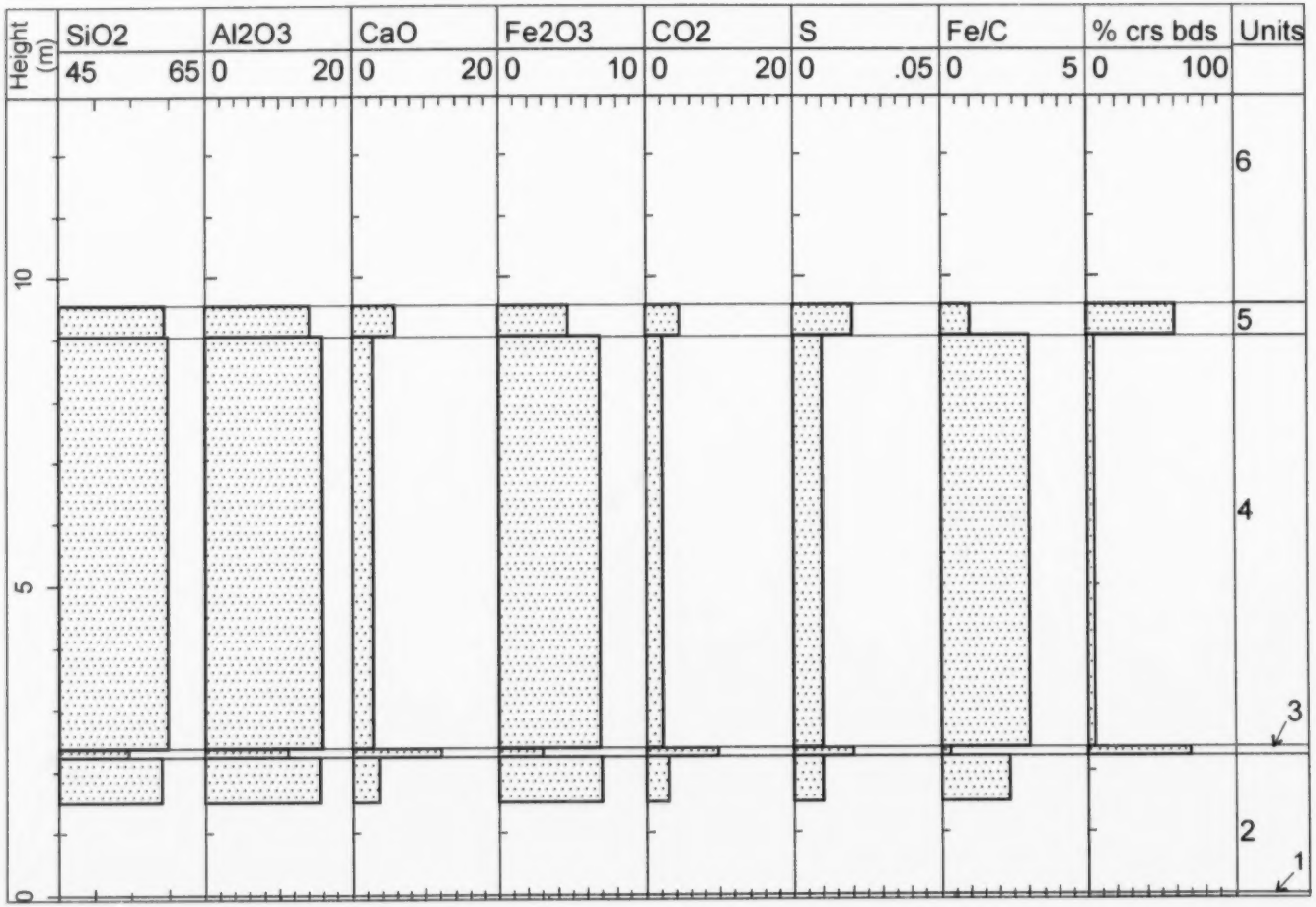

Figure 20: Plot of selected element oxide contents (in weight %) in composite samples from the Russell Quarry (station 01DKA-020). "Fe/C" = Fe2O3/CO2; "% crs bds" = per cent non-red shale components within a unit; "Units" = local lithologic units. Sample information is presented in Appendix 2 and the complete geochemical data set in Appendix 4.

Ceramic Testing

CERAMIC TESTING METHODOLOGY

Nine drill core samples of Queenston Formation shale were submitted to the National Brick Research Center (NBRC) in Anderson, South Carolina, for standard firing and properties testing. These 9 samples represent intervals of the Queenston Formation from various stratigraphic levels and 5 geographically separate locations. They were formed by combining contiguous composite samples from 5 cores (OGS-00-A1, OGS-00-A6, OGS-00-B1, OGS-00-B4 and OGS-00-C2) drilled in 2000 as part of this project. The relationship between the 9 ceramic testing samples and their original geochemical composite samples is presented in Table 16. Descriptions and geochemical analyses of the original composite samples were published in Armstrong (2001a, 2001b). The following description of the ceramic firing and properties testing methodology is taken from the explanatory notes that accompany MRD-92 (Armstrong and Frederic 2001).

Table 16: Relationship of ceramic testing samples to source drill holes and composite geochemical samples. For details about drill holes, original composite samples and lithologic units, see Armstrong (2001a, 2001b).

	Sample #	Drill Hole #	Composed of Composite Samples	Total Sample Interval			Lithologic Unit #
				Top Depth (m)	Bottom Depth (m)	Thickness (m)	
Group 1 samples	A1B	OGS-00-A1	00DKA145h to 00DKA145k	14.97	24.08	9.11	8 to 13
	B1B	OGS-00-B1	00DKA151g to 00DKA151o	18.30	34.43	16.13	8 to 16
	B4A	OGS-00-B4	00DKA152a to 00DKA152e	10.59	21.92	11.33	1 to 7
	A6B	OGS-00-A6	00DKA148f to 00DKA148j	16.53	26.10	9.57	6 to 11
	C2B	OGS-00-C2	00DKA154g to 00DKA154k	13.24	20.33	7.09	5 to 8
Group 2 samples	A1A	OGS-00-A1	00DKA145a to 00DKA145g	4.65	14.97	10.32	1 to 7
	A6A	OGS-00-A6	00DKA148b to 00DKA148e	6.55	16.53	9.98	1 to 5
	B1A	OGS-00-B1	00DKA151a to 00DKA151f	8.46	18.30	9.84	1 to 7
	C2A	OGS-00-C2	00DKA154a to 00DKA154f	0.00	13.24	13.24	1 to 4

The 9 samples were divided into 2 groups for ceramic testing: 5 samples (A1B, B1B, B4A, A6B and C2B) constituting Group 1; and 4 samples (A1A, A6A, B1A and C2A) making up Group 2 (Table 16). Group 2 samples represent the uppermost intervals of 4 geographically separate drill holes (drill hole locations are plotted on Figure 1a (back pocket)). Group 1 samples represent deeper stratigraphic intervals in these 4 holes and the uppermost part of another core, OGS-00-B4; that portion located immediately below the thick drift cover. The first 2 digits in each sample number refers to the last 2 digits of the drill hole number (*see* Table 16).

All samples in both groups were tested for thermal expansion (TDA); simultaneous differential thermal analysis and thermal gravimetric analysis (DTA/TGA); maturing range by gradient firing (to determine optimum firing temperatures for other tests); and loss on ignition (LOI) at 1000°C (1832°F). In addition, Group 2 samples were tested for: dried and fired shrinkage; modulus of rupture (MOR); cold and boiled absorption; efflorescence; density; and porosity.

All 9 samples were prepared at the NBRC by blending together rejects from the respective original geochemical samples (*see* Table 16) and then grinding them to –8 mesh (i.e., less than 2.38 mm). Lab bars, measuring 1″ x 1″ x 6” (2.54 cm x 2.54 cm x 15.24 cm), from all samples in Group 2 and 1 sample in Group 1 were extruded at very high penetrometer hardness using 20 to 24% moisture content. For those samples of Group 1 that would not extrude, specimens were pressed into “pucks”, so that the required tests could be completed.

All materials were very hard to extrude and several overloaded the extruder motor. Even the addition of oil to the shale mix and a coating of oil inside the extruder barrel and die did not solve the problem. These shales seem to have an excess of fine particles and lack of extrudability on a lab scale, even at high moisture contents (J.C. Frederic, personal communication, National Brick Research Center, 2001).

All lab bars were weighed and marked for shrinkage. Five bars from each of the Group 2 samples were tested for green strength (MOR) using a Hogue hydraulic tester. The rest of the Group 2 bars were dried in a lab drier at 110°C (230°F) for 24 hours. These dry bars were measured for shrinkage and 5 more bars from each sample were tested for dried strength (MOR) in the Hogue tester. Five more bars from each sample were fired (see specifications below) and then tested for fired strength (MOR) in the Hogue tester.

A specimen was cut from one dried bar from each sample (of both Groups 1 and 2) and tested for thermal expansion (in air) in an Orton dilatometer. The thermal expansion curves, showing the heating cycle up to 1100°C (2012°F) and the subsequent cooling cycle, are included here in Appendix 8.

Another specimen from the dried bars (both Group 1 and 2 samples) was analyzed using simultaneous DTA/TGA techniques in a Netzsh STA 449C unit. The evolved gases were analyzed in a FTIR (Fourier-transformed infrared) unit. These specimens, each approximately 50 mg, were heated at 10°C/minute to 1000°C (1832°F) in an atmosphere of 80% nitrogen and 20% oxygen. The resulting DTA/TGA plots are presented in Appendix 8.

Special bars, measuring 1″ x 1″ x 14″ (2.54 cm x 2.54 cm x 35.56 cm) were extruded (Group 1 and 2 samples) for the gradient test. As mentioned above, when extrusion of the bars was not possible, pressed "pucks" were used instead. These samples (bars and pucks) were fired in an electric gradient furnace with a temperature range of approximately 1900 to 2100°F (1039 to 1149°C). The temperature limits were selected from previous test data on materials from the same geographic area. These samples were evaluated for colour and firing range. A maximum firing temperature of 1950°F (1066°C) was selected for the other test bars. Above this temperature, the colour began to darken and, in most cases, turn to a greenish brown.

All remaining samples (Group 2) were fired in a gas kiln using a gradual heating curve and a 2-hour "soak" at maximum temperature (1950°F or 1066°C). The fired specimens were measured for shrinkage and tested for 24-hour cold water adsorption (CWA), 5-hour boiled water absorption (BWA), C/B (calculated by dividing CWA by BWA) and efflorescence according to the procedures in ASTM C67, "Standard Methods of Sampling and Testing Brick and Structural Clay Tile". They were also measured for density and porosity according to the procedures in ASTM C20, "Standard Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water".

CERAMIC TESTING RESULTS

Detailed ceramic or firing testing results are presented in Appendix 8, and were originally published in MRD 92 (Armstrong and Frederic 2001). They are summarized in Table 17 along with geochemical data from composite samples for their respective sample intervals.

The resulting DTA/TGA data are shown in the plots (Figures 8-10 to 8-18) in Appendix 8 as TG or thermogravimetric (solid line) and DTG or derivative thermogravimetric (dashed and dotted line) curves for weight loss, and evolved gas analysis for H_2O and CO_2 (dotted line and dashed line, respectively). The DTG curve illustrates at what temperature changes occur and the magnitude of these changes. The DTA curve (which shows endothermic and exothermic reactions) has been combined with the FTIR data to produce the CO_2 and H_2O curves. Peaks in the H_2O curve are related to the loss of mechanically bound water and at higher temperatures to dehydroxylation (labeled on plots in Appendix 8). Peaks in the CO_2 curve are caused by carbon burnout and carbonate mineral decomposition; note the corresponding deflections in the thermogravimetric (TG) curve (Appendix 8).

Table 17: Summary of ceramic test results and selected geochemical analyses for Group 2 core samples of the Queenston Formation. The complete data set is presented in Appendix 8 and in Armstrong and Frederic (2001). Geochemcial data are weighted averages (method explained in "Composite Sample" section of "Geochemical Results" section) of data from corresponding composite samples. Note: strength = modulus of rupture; psi = pounds per square inch.

Drill Holes:		OGS-00-A1	OGS-00-A6	OGS-00-B1	OGS-00-C2
Sample #:		A1A	A6A	B1A	C2A
Depth range of sample below surface in drill hole:		4.65 - 14.97 m	6.55 – 16.53 m	8.46 – 18.30 m	0 – 13.24 m
Firing and Properties Tests	dry shrinkage (%)	0.73	1.67	2.90	3.12
	fired shrinkage (%)	0.35	0.46	1.03	0.92
	total shrinkage (%)	1.12	2.15	3.89	4.13
	cold absorption (%)	17.57	19.75	13.91	15.38
	boiled absorption (%)	20.58	21.28	16.85	18.08
	cold/boiled absorptions	0.85	0.93	0.83	0.85
	density (g/cc)	1.76	1.75	1.80	1.72
	porosity (%)	36.16	37.28	30.37	31.05
	green strength (psi)	125.3	124.0	141.9	164.4
	dried strength (psi)	186.8	142.7	188.7	219.6
	fired strength (psi)	786.8	733.0	1257.4	1283.9
	efflorescence	yes	yes	yes	yes
	fired colour	tan with white discolouration	light pinkish tan with white discolouration	medium pinkish tan	light pinkish tan
Geochemistry	LOI (%)	15.99	15.36	15.54	15.61
	CO_2 (%)	12.43	11.13	11.11	11.86
	CaO (%)	15.09	12.99	12.86	12.38
	SiO_2 (%)	44.24	45.63	43.99	41.83
	Al_2O_3 (%)	11.33	12.31	13.16	14.01
	Fe_2O_3 (%)	4.91	4.95	5.51	6.13
	Fe_2O_3/CO_2	0.39	0.44	0.50	0.52

The 9 sample intervals were selected to provide information on the brick-making potential of the Queenston Formation at various stratigraphic levels and geographic areas: samples A1A and A1B are from the middle of the Queenston Formation near Burlington; samples A6A and A6B are from the middle part of the formation, south of Georgetown; samples B1A and B1B are from the upper part of the formation west of Mansfield; sample B4A is from the lower part of the formation north of Creemore; and samples C2A and C2B are from the uppermost part of the formation, northwest of Meaford.

Samples B1A and C2A yielded the best overall results (J.C. Frederic, personal communication, National Brick Research Center, 2002). They have the highest amount of clay, lowest SiO_2, highest Fe_2O_3, highest strength values (Table 17) and relatively normal thermal expansion plots (Appendix 8; Armstrong and Frederic 2001).

Summary and Conclusions

The following summary and conclusions regarding shale resources in southern Ontario are based upon the results of both phases of this study (i.e., this report and Armstrong 2001b).

In the initial phase of this study, the properties of the Queenston Formation in existing active quarries were studied in order to provide empirical guidelines for evaluating this formation on a regional scale. Key results from the initial phase of the study (Armstrong 2001b), included

- the carbonate content in the Queenston Formation (a prime factor in determining brick colour) appears to be largely controlled by calcite content, and the relative carbonate content is effectively approximated by CO_2 content;
- calcite is common in both the shale and non-shale (i.e., calcareous siltstone and sandstone beds) components of the formation;
- Queenston Formation with a CO_2 content up to 10% yields red coloured bricks, whereas, where the formation has a CO_2 content ranging from 10 to 15% it yields yellow-buff coloured bricks (shale with a higher average CO_2 content was not encountered in the presently active quarries);
- the middle part of the Queenston Formation is the most calcareous (the Burlington Quarry is located in this part of the formation and produces yellow-buff coloured bricks);
- gypsum (a deleterious component in brick making) occurs in most of the active quarries, however, its presence is not commonly indicated as an elevated sulphur content in geochemical analysis, because there appears to be little sulphur in the matrix in the vicinity of gypsum nodules or fracture-filling gypsum (i.e., the nodule or fracture must be sampled to indicate its presence);
- confirmation that the Queenston Formation as a whole becomes more calcareous towards the north, and that the middle part of the formation remains the most calcareous part of the formation (includes significant fossiliferous limestone beds) in the north;
- in the northern part of its outcrop belt, northwest of Collingwood, intervals of the Queenston Formation, especially toward the top and bottom of the formation, have carbonate contents comparable with the middle part of the formation in the south (i.e., 10 to 15% CO_2);
- in a core through the whole formation at Milton (drill hole OGS-83-1), gypsum nodules and fracture-fillings occur from approximately 50 m below the top of the Queenston Formation and throughout the remainder of the formation (a further 110 m down this hole), although they are most abundant in a zone from 50 to 60 m below the top;
- the general stratigraphic distribution of gypsum in the northern part of the outcrop belt (e.g., drill hole OGS-00-C1) is similar to that observed in the Milton core.
- 2 drill holes, OGS-00-A8 and OGS-00-A10, encountered thicker drift than expected.

Additional results concerning the Queenston Formation from the second phase of this study (this report) include

- in eastern Ontario, the Queenston Formation is less calcareous and more siliceous than in its main outcrop belt;
- an additional 10 m of Queenston Formation strata underlie the Russell Quarry in eastern Ontario;
- the ratio of Fe_2O_3 to CO_2 is an indicator of brick colour for the Queenston Formation, and a review of the 2000 data indicates that ratios greater than 0.50 yield red coloured bricks;
- in the northern part of the Queenston Formation's main outcrop belt (i.e., the Meaford area), there is up to 30 m at the top of the formation with a carbonate content that would yield yellow-buff (or tan) coloured bricks (i.e., average CO_2 content ranging from 10 to 15%);
- Queenston Formation shales tend to have higher levels of fluorine (F) than its non-shale constituents, and the upper (i.e., shalier) part of the formation tends to have higher F values;
- ceramic testing indicates that the upper Queenston Formation in the northern part of its outcrop belt is better for making bricks than some parts of the Queenston Formation in its traditional area of extraction (i.e., the Oakville–Hamilton–Brampton area).

The Georgian Bay and Blue Mountain formations were also examined in the second phase of this study. Key characteristics of these formations and results from that phase of this study include

- both formations are shale-dominated and contain non-shale interbeds of calcareous siltstone and sandstone and bioclastic limestone, informally termed hard beds or hard bands;
- the Georgian Bay Formation contains a higher proportion of hard beds and the contact between this formation and the underlying Blue Mountain Formation is gradational and arbitrary;
- both formations contain alternating shale-dominated intervals and intervals of interbedded shale and "hard beds"; some workers have interpreted paired shale-dominated and interbedded intervals to represent shallowing upward cycles;
- interbedded intervals are more prevalent in the Georgian Bay Formation and hard beds tend to be thicker there than in the Blue Mountain Formation;
- shale-dominated intervals are thicker in the Blue Mountain Formation;
- up to 10 m at the top of the Georgian Bay Formation contains fewer distinct shale-dominated intervals, more hard beds, especially bioturbated argillaceous bioclastic limestone, and may represent the informally termed upper member of Liberty (1969);
- hard beds in the Georgian Bay Formation are more calcareous (higher CaO and CO_2 contents) to the north;

- Georgian Bay shales appear to become more clay-rich (higher Al_2O_3 content) to the north;
- the shale components of these 2 formations are geochemically very similar, except for: higher CO_2 values in the Blue Mountain Formation shale due to higher organic-carbon content (especially in the south) and higher sulphur content in the Blue Mountain Formation shales;
- compared with the average composition of Queenston Formation shales, the Georgian Bay and Blue Mountain formation shales are non-calcareous.
- the Georgian Bay Formation is a proven source of raw material for brick making (e.g., Guillet 1967), and sufficiently thick shale-dominated intervals occur throughout the formation and under areas of thin drift along its outcrop belt;
- although the Blue Mountain Formation has not been utilized for making bricks, previous workers (e.g., Guillet 1977; Martini and Kwong 1986) report that this formation has favourable ceramic properties, but that its relatively high sulphur content may need to be addressed during processing.

Key factors governing access to potential shale resources covered by this study include

- thick drift over most of the Blue Mountain Formation outcrop belt limits access to virtually all of this formation;
- thick drift cover over the middle part of the Georgian Bay and Queenston formation outcrop belts focuses potential resource development to the southern and northern parts of their outcrop belts;
- widespread urban development virtually eliminates access to the Blue Mountain and Georgian Bay formations in the Toronto area;
- increasing urban expansion in the areas west of Toronto and east of Hamilton are reducing access to resources in the Queenston Formation;
- intense and significant agricultural use competes for access to high quality resources of the Queenston Formation on the Niagara Peninsula;
- restrictions to resource development in the Niagara Escarpment Plan Area severely limit access to the high quality resources in the upper Queenston Formation, and to all 3 formations in their northern outcrop belts (e.g., the Collingwood–Thornbury area);
- urban development in the Ottawa area severely limits access to the Billings (equivalent to the Blue Mountain) and Carlsbad (equivalent to the Georgian Bay) formations;
- thick drift cover in eastern Ontario results in limited access to potential shale resources in the Carlsbad and Queenston formations there.

Recommendations

All thin drift areas over the Queenston Formation in the southern part of its outcrop belt (i.e., in the Niagara Peninsula area and the Regional Municipalities of Halton and Peel) should be considered for resource protection. The only shale resource in this formation that will yield red coloured bricks is located within the upper and lower parts of the formation in this region and in eastern Ontario.

Thin drift areas over the upper or lower parts of the Queenston Formation in the central and northern parts of its main outcrop belt (i.e., the Rosemont–Mansfield, Duntroon, southeast and northwest Meaford areas) should be considered for resource protection.

Thin drift-covered areas over the Georgian Bay Formation in the Rosemont and southeast Meaford areas should be considered for resource protection. Available thin drift areas over the Georgian Bay Formation in the Brampton area should also be considered for resource protection.

The thin drift area over the Blue Mountain Formation southeast of Meaford should be considered for resource protection.

Thin drift areas over the Queenston and Carlsbad formations in eastern Ontario should be considered for resource protection.

Individual thin drift areas should be examined in detail and confirmed before proceeding with site-specific resource evaluation or development.

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Appendix 1

Mapping station information
(*from* Armstrong and Sergerie 2002a, 2002b)

Appendix 1: Mapping station information (UTM coordinates in NAD 83, except ** in NAD 27; all UTM locations in Grid Zone 17, except * and ** in Grid Zone 16; station types: d = drill hole, o = outcrop, x = excavation or road cut, q = quarry; formation codes: Q = Queenston, G = Georgian Bay, B = Blue Mountain, C = Carlsbad, Bi = Billings).

Station #	Location Name	UTM Easting	UTM Northing	NTS map #	Station Type	Section height or interval thickness (m)	# of lithologic units or sections (#s)	Station Description	Station Datum	Formation
01DKA-001	Don Valley Brick Yard, Toronto	631608	4838480	30 M/11	q	2.75	5	station at storm drain, on west side of park in former shale quarry.	base of outcrop	G
01DKA-002	Mimico Creek, Etobicoke	621647	4831679	31 M/11	o	5.00	2	outcrop on west bank, south of bridge (Queensway Blvd.).	creek water level	G
01DKA-003	Etobicoke Creek, Etobicoke	613850	4833150	30 M/12	o	6.85	4	on east bank, south of Rathburn St.	creek water level	G
01DKA-004	Credit River (at Eglinton Rd.)	605530	4825036	30 M/12	o	~ 6.00	6	on west bank, south of Eglinton Rd.; access via Croatian Club off Mississauga Rd.	river water level	G
01DKA-005	Credit River (at Burnham-thorpe)	607698	4823386	30 M/12	o	~ 8.50	5	section on west bank, not accessible; viewed from east bank at Erindale Park.	river water level	G
01DKA-006	Credit River (at Dundas St.)	608495	4821948	30 M/12	o	~ 8.00	not determined	section on west bank, south of Dundas; section is not accessible, viewed from east bank.	river water level	G
01DKA-007	Rouge River (Rouge River Park)	648697	4852904	30 M/14	o	2.30	1	outcrop on east bank of Rouge River, downstream from parking lot at Twyn River Rd.	river water level	B

Station #	Location Name	UTM Easting	UTM Northing	NTS map #	Station Type	Section height or interval thickness (m)	# of lithologic units or sections (#s)	Station Description	Station Datum	Formation
01DKA-008	Humber River (Etienne Brule Park)	621671	4833995	30 M/11	o	8.85	6	outcrop on east bank, north of Bloor St. bridge; section includes 3.5 m covered at base.	river water level	G
01DKA-009	Century Brick Plant (Hamilton)	595308	4787611	30 M/4	q	~ 23.95	3	Lawrence Ave., Hamilton; old quarry wall behind present brick plant (former Hamilton Brick Ltd. quarry).	base of quarry wall	Q
01DKA-010	Burnstein Quarry, St. Davids	652449	4781585	30 M/6	q	1.36	1	Canada Brick Ltd. Property; at corner of 8th Line and 5th Concession, Niagara Twp, northwest of St. Davids.	water level in sump pond	Q
01DKA-011	Duntroon Quarry core (OGS-80-1)	561488	4915422	41 A/8	d	88.75	30	core stored at OGSR Core Lab in London; section thickness is total Queenston Fm. interval only; total depth drilled = 98.07 m.	ground surface	Q,G
01DKA-012	Adjala Twp, east of Rosemont	584677	4885965	31 D/4	x	< 0.25	1	poor outcrop in drainage ditch in field, east side of Con. 4 Road.	lowest visible bed	G
01DKA-013	Adjala Twp, southeast of Rosemont	584798	4884956	31 D/4	x	6.70	7	series of 4 small outcrops in ditch on west side of Con. 4 Road.	base of roadcut	G
01DKA-014	Mansfield ski hill	575283	4893894	41 A/1	x	8.00	4	road cut on north side of 15 Side Road, near Mansfield ski hill.	base of roadcut	Q
01DKA-015	Whitfield, east of Mansfield	571269	4889549	41 A/1	x	15.70	4	northeast side of County Road 17, east of Whitfield, west of Mansfield.	base of roadcut	Q

Station #	Location Name	UTM Easting	UTM Northing	NTS map #	Station Type	Section height or interval thickness (m)	# of lithologic units or sections (#s)	Station Description	Station Datum	Formation
01DKA-016	Perm, east of Mansfield	574198	4890913	41 A/1	x	14.80	7	road cut on both sides of 4th Line East Rd, north of Perm.	base of roadcut	Q
01DKA-017	Lavender Badlands, south of Creemore	570619	4902899	41 A/8	x, o	21.65	7	outcrop and roadcut on east side of 3rd Line East Rd, Mulmur Twp., ~ 4 km east of Lavender.	base of roadcut	Q
01DKA-018	Southeast Claybanks, Christie Beach	535834	4937875	41 A/10	o	~ 46.25	8	large cliff outcrop on shore of Georgian Bay, west of Christie Beach, southeast of Meaford; section measured at east end of cliff; includes 9.7 m covered interval at base.	lake water level	G,B
01DKA-019	East Meaford (Workman's) Creek	535090	4937371	41 A/10	o	~ 98.50	37s	series of 37outcrops in river banks, upstream from Georgian Bay to ~ 2.5 km south.	lake water level	G,B
01DKA-020	Russell Quarry, Russell (Ottawa area)	470890*	5016292*	31 G/6	q	12.95	6	sections measured on west and north walls of quarry.	quarry floor	Q
01DKA-021	GSC Russell Well	469400**	5017600**	31 G/6	d	14.00 (Q) 27.00 (G)	not determined	core stored at Geological Survey of Canada core repository in Ottawa; core not sampled.	ground surface	Q,C, Bi

Station #	Location Name	UTM Easting	UTM Northing	NTS map #	Station Type	Section height or interval thickness (m)	# of lithologic units or sections (#s)	Station Description	Station Datum	Formation
01DKA-022	Sucker Creek, northwest Meaford	521379	4951115	41 A/10	o	~ 38.20	20s	series of 20 outcrops in banks of Sucker Creek, from Georgian Bay to ~ 1.4 km south (on Canadian Forces Training Area Meaford property).	lake water level	G
01DKA-024	Christie Beach Creek	538730	4937627	41 A/10	o	~ 35.50	15s	series of 15 outcrops on both sides of creek, less than 1 km south of Gerogian Bay.	lake water level	B
01DKA-025	Loree, southeast of Thornbury	549323	4928930	41 A/9	x	21.50	4	exposures on both sides of the 21st Side Road; ~3.5 km east of Victoria Corners; includes 9.0 m covered interval in middle.	base of roadcut	Q
01DKA-026	Silcote, northeast of Owen Sound	517933	4945516	41 A/10	x	3.50	2	on east side of 2nd Con. Rd. N., ~ 0.8 km north of Silcote.	base of roadcut	Q
01DKA-027	Silcote north	517819	4946265	41 A/10	x	3.50	5	on east side of 2nd Con. Rd. N., ~1.4 km north of Silcote; covered by 4.5 m of overburden.	base of roadcut	Q
01DKA-028	South of Christie Beach	538029	4935057	41 A/10	x	2.55	1	south side of 7th Side Road, west of Collingview St.	base of roadcut	Q
01DKA-029	Southeast of Meaford	536272	4934536	41 A/10	x	3.15	1	on both sides of the 7th Side Road, west of 3rd Line.	base of roadcut	Q

Station #	Location Name	UTM Easting	UTM Northing	NTS map #	Station Type	Section height or interval thickness (m)	# of lithologic units or sections (#s)	Station Description	Station Datum	Formation
01DKA-030	drill hole OGS-01-01	598950	4850250	30 M/13	d	30.5	10	northeast of Tullamore, northeast of Brampton: west side of Gore Way Drive, ~550 m south of Mayfield Road.	ground surface	G
01DKA-031	drill hole OGS-01-02	584657	4885765	31 D/4	d	35.47	8	east of Rosemont, west of Alliston: west side of Concession 4 Road, ~1.2 km south of 30th Side Road, Adjala Twp.	ground surface	G
01DKA-032	drill hole OGS-01-03	538606	4937283	41 A/10	d	42.52	15	east of Meaford: east side of Christie Beach Road, ~0.95 km north of Hwy. 26, ~250 m north of 39th Side Road, Collingwood Twp.	ground surface	B
01DKA-033	drill hole OGS-01-04	536270	4936455	41 A/10	d	61.08	23	southeast of Meaford: on north side of 10th Side Road, < 250m east of 3rd Line Rd, ~2 km north of 7 Side Road, St. Vincent Twp.	ground surface	Q,G
01DKA-034	drill hole OGS-01-05	519274	4948872	41 A/10	d	58.68	33	Balaclava, northwest of Meaford: on north side of 10th Side Road, < 250 m east of 3rd Line Rd, ~2 km north of 7 Side Road, Sydenham Twp.	ground surface	Q,G
01DKA-035	drill hole OGS-01-06	470909*	5016616*	31 G/6	d	59.46	21	Russell Quarry, east of Ottawa, ~5 km north of Russell.	ground surface	Q,C

Appendix 2

Field composite sample information (from Armstrong and Sergerie 2002a)

Appendix 2: Field composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations; all samples are Queenston Formation, unless otherwise noted in Sample Description).

Sample #	Height/depth (m)		Location Name	Sample Description	Litho-logic Unit #
	From	To			
01DKA110a	0.25	2.25	Burnstein Quarry	red shale from old stockpile	n/a
01DKA111a	1.55	3.20	Duntroon core OGS-80-1	grey-green shale and siltstone	2
01DKA111b	3.20	4.45	Duntroon core OGS-80-1	red-brown shale	3
01DKA111c	4.45	6.05	Duntroon core OGS-80-1	red-brown shale with minor small green mottles	3
01DKA111d	6.05	7.70	Duntroon core OGS-80-1	red-brown shale with small green mottles/beds (<10%)	4
01DKA111e	7.70	9.45	Duntroon core OGS-80-1	red (70%) and green (30%) shale	5
01DKA111f	9.54	10.93	Duntroon core OGS-80-1	red shale with minor green mottles	6
01DKA111g	11.35	12.58	Duntroon core OGS-80-1	red-brown shale (60%) and green shale (40%)	6
01DKA111h	12.88	15.00	Duntroon core OGS-80-1	mostly red shale	6
01DKA111i	15.00	15.72	Duntroon core OGS-80-1	green shale (~50%) and red shale (~50%)	7
01DKA111j	16.40	17.89	Duntroon core OGS-80-1	red shale with medium to large green mottles (<20%)	8
01DKA111k	18.18	20.07	Duntroon core OGS-80-1	red shale with minor green mottles/beds (<10%)	8
01DKA111l	20.24	21.91	Duntroon core OGS-80-1	mostly red shale, with minor green mottles	8
01DKA111m	21.91	24.27	Duntroon core OGS-80-1	red shale with green shale	8
01DKA111n	24.70	25.68	Duntroon core OGS-80-1	mostly red shale	8
01DKA111o	25.68	26.70	Duntroon core OGS-80-1	green shale (~70%; top 35 cm of unit) and red shale (30%)	9
01DKA111p	26.70	28.21	Duntroon core OGS-80-1	mostly red shale, with green siltstone/shale and small gypsum nodules	10
01DKA111q	28.21	29.83	Duntroon core OGS-80-1	red shale (70%) with green shale beds (30%)	11
01DKA111r	30.37	32.34	Duntroon core OGS-80-1	red shale	12
01DKA111s	32.34	33.84	Duntroon core OGS-80-1	50% red shale, 50% green shale	13
01DKA111t	33.84	36.20	Duntroon core OGS-80-1	red shale with minor green mottles (<20%)	13
01DKA111u	36.20	38.31	Duntroon core OGS-80-1	red shale with few green beds/mottles (<10%)	14
01DKA111v	39.14	40.54	Duntroon core OGS-80-1	red shale (70%) with green beds/mottles (30%)	15
01DKA111w	40.54	41.50	Duntroon core OGS-80-1	red shale with 20% green beds	15
01DKA111x	41.50	42.18	Duntroon core OGS-80-1	mostly green shale, with minor light red shale interbeds	16
01DKA111y	42.62	44.98	Duntroon core OGS-80-1	red shale (less calcareous than typical), with light green siltstone/shale beds and mottles (< 10%)	17
01DKA111z	45.67	47.75	Duntroon core OGS-80-1	red shale (60%) with green/light green shale/siltstone beds (40%)	18

Sample #	Height/depth		Location Name	Sample Description	Litho-logic
	From	To			
01DKA111aa	47.75	48.66	Duntroon core OGS-80-1	green/grey shale/siltstone, with red mottles and gypsum nodules	19
01DKA111ab	48.66	50.15	Duntroon core OGS-80-1	red (60%) and green (40%) shale, with small white gypsum nodules	20
01DKA111ac	50.15	51.40	Duntroon core OGS-80-1	red and green shale (50/50), with gypsum nodules and seams	20
01DKA111ad	51.40	52.66	Duntroon core OGS-80-1	mostly green calcareous siltstone with minor red calcareous shale	21
01DKA111ae	52.98	55.12	Duntroon core OGS-80-1	red shale (75%) with green shale and siltstone (20%) and light red siltstone (5%) and gypsum nodules and seams	22
01DKA111af	55.60	56.93	Duntroon core OGS-80-1	red shale (65%) with interbeds of interlaminated green and light green shale (20%), light red siltstone (5%) and green shale (10%), and a few gypsum nodules	22
01DKA111ag	56.93	58.31	Duntroon core OGS-80-1	interbedded red and green (60/40) shales and silstones, with large gypsum nodules and thick seams	23
01DKA111ah	58.31	59.90	Duntroon core OGS-80-1	mostly green shale and siltstone, with minor (~10%) red shale, and gypsum nodules and seams	24
01DKA111ai	59.90	61.31	Duntroon core OGS-80-1	interbedded red (30%) and green shale, and light green and red siltstone, with gypsum nodules and seams	25
01DKA111aj	61.31	62.90	Duntroon core OGS-80-1	similar to sample 01DKA111ai	25
01DKA111ak	62.90	64.57	Duntroon core OGS-80-1	mostly siltstones with minor red (~10%) and green shale and fewer gypsum seams than above	25
01DKA111al	64.57	66.02	Duntroon core OGS-80-1	similar to 01DKA111ak, except more (20%) red shale and sparse gypsum nodules and seams	25
01DKA111am	66.66	68.38	Duntroon core OGS-80-1	red shale (60%) with light green and red siltstone and green shale, some gypsum seams and nodules	26
01DKA111an	68.38	69.83	Duntroon core OGS-80-1	similar to 01DKA111am, but less (~25%) red shale and large gypsum nodules	26
01DKA111ao	70.31	71.82	Duntroon core OGS-80-1	red shale (40%) with light green and red siltstone and green shale, and large white gypsum nodules	26
01DKA111ap	71.82	73.58	Duntroon core OGS-80-1	similar to 01DKA111ao	26
01DKA111aq	73.58	74.94	Duntroon core OGS-80-1	similar to 01DKA111ao	26
01DKA111ar	74.94	76.59	Duntroon core OGS-80-1	similar to 01DKA111ao, with thicker red shale beds, gypsum nodules and seams	26
01DKA111as	76.59	78.03	Duntroon core OGS-80-1	interbedded red shale (20%) and light red and green siltstones and green shale and small gypsum nodules	26

Sample #	Height/depth		Location Name	Sample Description	Litho-logic
	From	To			
01DKA111at	78.03	79.42	Duntroon core OGS-80-1	red shale (85%) with thin green shale/siltstone interbeds	27
01DKA111au	79.42	81.30	Duntroon core OGS-80-1	red shale (80%) with thin green shale/siltstone interbeds	27
01DKA111av	81.30	83.22	Duntroon core OGS-80-1	red shale (90%) with thin green shale/siltstone interbeds	27
01DKA111aw	83.22	84.68	Duntroon core OGS-80-1	red shale (50%) with green shale and light green and red siltstone	28
01DKA111ax	84.68	86.31	Duntroon core OGS-80-1	similar to 01DKA111aw	28
01DKA111ay	86.31	87.67	Duntroon core OGS-80-1	mostly red shale, thinly interbedded to interlaminated with green shale and light red and green siltstone	29
01DKA111az	87.67	89.27	Duntroon core OGS-80-1	interlaminated to interbedded red and green shales and light red and green siltstones	29
01DKA111ba	89.27	90.30	Duntroon core OGS-80-1	thinly interbedded red (~30%) and green shale and light red and green siltstone, locally interlaminated.	29
01DKA111bb	90.30	92.10	Duntroon core OGS-80-1	interbedded grey, fine-grained, bioclastic limestone and green shale (Georgian Bay Formation)	30
01DKA120a	-0.07	0.00	Russell Quarry	red-brown to greenish red, rippled calcisiltite	1
01DKA120b	1.50	2.20	Russell Quarry	red shale	2
01DKA120c	2.20	2.35	Russell Quarry	green calcisiltite beds with green shale and minor red shale	3
01DKA120d	2.35	9.05	Russell Quarry	red shale with some small green mottles	4
01DKA120e	9.05	9.55	Russell Quarry	green calcisiltite beds with green shale and some red shale	5
01DKA120f	9.55	12.95	Russell Quarry	red shale with minor, thin, discontinous green calcisiltite beds	6

Appendix 3

Field bed sample information
(*from* Armstrong and Sergerie 2002a)

Appendix 3: Field bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations; geochemically analyzed samples are indicated with "x" in last column; formations: Q = Queenston, G = Georgian Bay, B = Blue Mountain, C = Cabot Head, W = Wingfield; for information about series 00DKAxxx samples (last 7 in this table), see Armstrong 2001a or 2001b).

Sample #	Elevation (m)		Location Name	Sample Description	Lithologic Unit or Section (s) #	Formation	Analyzed
	from	to					
01DKA001a	1.30	1.40	Don Valley Brick Yard	grey shale	3	G	x
01DKA001b	1.70	1.75	Don Valley Brick Yard	grey limestone	4	G	
01DKA002a	0.40	0.50	Mimico Creek	grey shale	1	G	x
01DKA002b	0.45	0.47	Mimico Creek	fine-grained, grey limestone	1	G	
01DKA002c	3.10	3.20	Mimico Creek	grey shale	2	G	x
01DKA002d	3.40	3.45	Mimico Creek	fossiliferous limestone	2	G	
01DKA003a	1.15	1.25	Etobicoke Creek	grey shale	1	G	x
01DKA003b	1.50	1.55	Etobicoke Creek	limestone	1	G	
01DKA003c	1.90	1.95	Etobicoke Creek	fossiliferous limestone	2	G	
01DKA003d	2.60	2.65	Etobicoke Creek	tabular bedded, laminated limestone	2	G	x
01DKA003e	3.25	3.35	Etobicoke Creek	grey shale	3	G	x
01DKA004a	0.05	0.10	Credit River (at Eglinton)	grey limestone with fossil lag (calcisiltite)	1	G	x
01DKA004b	1.00	1.05	Credit River (at Eglinton)	tabular, grey limestone (calcisiltite)	1	G	
01DKA004c	1.20	1.25	Credit River (at Eglinton)	red to grey siltstone, base of "ball bed"	1	G	
01DKA004d	1.60	1.70	Credit River (at Eglinton)	grey shale	1	G	x
01DKA004e	1.80	1.90	Credit River (at Eglinton)	fossiliferous, grey limestone	1	G	
01DKA007a	0.05	0.10	Rouge River	grey shale	1	B	x
01DKA007b	0.45	0.50	Rouge River	black shale	1	B	x
01DKA007c	1.10	1.20	Rouge River	grey shale	1	B	x
01DKA007d	1.70	1.75	Rouge River	grey shale	1	B	x

Sample #	Elevation (m)		Location Name	Sample Description	Lithologic Unit or Section (s) #	Formation	Analyzed
	from	to					
01DKA008a	3.10	3.15	Humber River	grey, laminated limestone (calcisiltite)	1	G	x
01DKA008b	5.15	5.25	Humber River	grey shale	2	G	x
01DKA008c	5.40	5.42	Humber River	laminated limestone (calcisiltite)	3	G	
01DKA008d	5.70	5.75	Humber River	bioclastic limestone	3	G	
01DKA008e	5.95	6.00	Humber River	tabular, laminated limestone	3	G	x
01DKA008f	6.15	6.20	Humber River	shale	3	G	x
01DKA008g	6.20	6.25	Humber River	limestone	4	G	x
01DKA008h	n/a	n/a	Humber River	green-grey siltstone (float from top of "ball bed")	6	G	x
01DKA009a	4 95	5.00	Century Brick (Hamilton)	red shale	1	Q	x
01DKA009b	7.35	7.70	Century Brick (Hamilton)	green siltstone with green shale	1	Q	x
01DKA009c	8.55	8.70	Century Brick (Hamilton)	red shale	1	Q	x
01DKA009d	11.65	11.95	Century Brick (Hamilton)	red shale	1	Q	x
01DKA009e	14.35	14.45	Century Brick (Hamilton)	red shale	1	Q	x
01DKA009f	19.55	19.65	Century Brick (Hamilton)	red shale	1	Q	x
01DKA010a	0.59	0.64	Bernstein Quarry	red shale	1	Q	x
01DKA010b	0.64	0.69	Bernstein Quarry	green siltstone	1	Q	x
01DKA010c	0.69	0.74	Bernstein Quarry	red shale	1	Q	x
01DKA010d	0.98	1.08	Bernstein Quarry	red shale	1	Q	x
01DKA012a	0.20	0.25	east of Rosemont	grey bioclastic limestone	1	G	
01DKA013a	0.60	0.70	southeast of Rosemont	grey-green, clayey, shale	3	G	x
01DKA013b	3.10	3.20	southeast of Rosemont	shale	5	G	x
01DKA013c	2.95	3.05	southeast of Rosemont	limestone	5	G	x
01DKA013d	6.35	6.45	southeast of Rosemont	grey shale	7	G	x
01DKA014a	0.80	1.05	Mansfield ski hill road cut	red shale	1	Q	x

Sample #	Elevation (m)		Location Name	Sample Description	Lithologic Unit or Section (s) #	Formation	Analyzed
	from	to					
01DKA014b	2.20	2.30	Mansfield ski hill road cut	red shale	1	Q	x
01DKA014c	2.70	2.80	Mansfield ski hill road cut	green calcisiltite (limestone)	1	Q	x
01DKA014d	3.50	3.70	Mansfield ski hill road cut	red shale	1	Q	x
01DKA014e	3.70	3.75	Mansfield ski hill road cut	green calcisiltite (limestone)	2	Q	
01DKA014f	4.80	5.00	Mansfield ski hill road cut	red shale	3	Q	x
01DKA014g	5.40	5.70	Mansfield ski hill road cut	red shale	3	Q	x
01DKA014h	6.30	6.50	Mansfield ski hill road cut	red shale with minor green shale	3	Q	x
01DKA014i	7.60	7.65	Mansfield ski hill road cut	green shale and calcisiltite	4	Q	x
01DKA015a	1.50	1.60	Whitfield road cut	red shale	1	Q	x
01DKA015b	2.10	2.25	Whitfield road cut	green calcisiltite (limestone) with mudchips	1	Q	x
01DKA015c	3.50	3.60	Whitfield road cut	red shale	2	Q	x
01DKA015d	6.10	6.30	Whitfield road cut	red/brown shale	3	Q	x
01DKA015e	9.00	9.20	Whitfield road cut	green shale	3	Q	x
01DKA015f	9.40	9.45	Whitfield road cut	mineralized (quartz?) vug in green shale	4	Q	
01DKA015g	11.10	11.30	Whitfield road cut	red shale	4	Q	x
01DKA015h	13.50	13.60	Whitfield road cut	red shale (weathered?)	4	Q	x
01DKA016a	0.70	0.75	Perm road cut	red shale and light red siltstone	1	Q	x
01DKA016b	2.20	2.30	Perm road cut	red shale	2	Q	x
01DKA016c	5.50	5.60	Perm road cut	red shale	2	Q	x
01DKA016d	6.50	6.60	Perm road cut	green limestone	2	Q	x
01DKA016e	7.20	7.40	Perm road cut	red shale	3	Q	x
01DKA016f	9.80	10.10	Perm road cut	green and red shale	4	Q	x
01DKA016g	11.20	11.80	Perm road cut	red shale	5	Q	x
01DKA016h	12.60	12.80	Perm road cut	grey limestone and green shale	6	Q	x

Sample #	Elevation (m)		Location Name	Sample Description	Lithologic Unit or Section (s) #	Formation	Analyzed
	from	to					
01DKA016i	13.80	14.10	Perm road cut	red shale with green mottle (possibly weathered)	7	Q	x
01DKA017a	1.70	1.80	Lavender Badlands	red shale	2	Q	x
01DKA017b	5.40	5.42	Lavender Badlands	red shale	4	Q	x
01DKA017c	15.70	15.80	Lavender Badlands	green and red shale	6	Q	x
01DKA017d	16.80	16.90	Lavender Badlands	red shale with minor green mottles	6	Q	x
01DKA017e	17.55	18.25	Lavender Badlands	green shale	6	Q	x
01DKA017f	19.25	19.40	Lavender Badlands	red shale	6	Q	x
01DKA017g	20.05	20.25	Lavender Badlands	green shale (clayey)	7	Q	x
01DKA018a	10.48	10.50	southeast Claybanks	grey laminated limestone	2	B	x
01DKA018b	10.68	10.70	southeast Claybanks	grey bioclastic limestone	2	B	x
01DKA018c	10.70	12.10	southeast Claybanks	grey shale	2	B	x
01DKA018d	16.45	17.65	southeast Claybanks	grey shale	2	B	x
01DKA018e	19.00	20.00	southeast Claybanks	grey shale	2	B	x
01DKA018f	23.60	23.65	southeast Claybanks	grey laminated limestone	3	B	
01DKA018g	24.85	25.05	southeast Claybanks	grey shale	4	B	x
01DKA018h	30.40	30.60	southeast Claybanks	grey shale	4	B	x
01DKA018i	35.25	35.40	southeast Claybanks	grey shale	4	B	x
01DKA018j	37.90	38.00	southeast Claybanks	grey shale	6	G	x
01DKA019a	21.25	21.55	East Meaford Creek	grey shale	s9	B	x
01DKA019b	29.20	29.50	East Meaford Creek	grey shale	s11	B	x
01DKA019c	30.95	31.05	East Meaford Creek	grey shale	s13	G	x
01DKA019d	31.75	31.80	East Meaford Creek	bioclastic argillaceous limestone	s13	G	x
01DKA019e	35.35	35.40	East Meaford Creek	laminated, grey limestone	s14	G	x
01DKA019f	36.15	36.25	East Meaford Creek	grey shale	s14	G	x

Sample #	Elevation (m)		Location Name	Sample Description	Lithologic Unit or Section (s) #	Formation	Analyzed
	from	to					
01DKA019g	35.90	36.20	East Meaford Creek	grey shale	s15	G	x
01DKA019h	38.05	38.15	East Meaford Creek	grey shale	s15	G	x
01DKA019i	41.00	41.10	East Meaford Creek	grey shale	s17	G	x
01DKA019j	41.65	41.85	East Meaford Creek	grey shale, with ~20% fossiliferous limestone	s17	G	x
01DKA019k	41.80	41.85	East Meaford Creek	laminated, grey limestone	s17	G	
01DKA019l	47.25	47.45	East Meaford Creek	grey shale	s18	G	x
01DKA019m	48.90	49.00	East Meaford Creek	grey shale	s19	G	x
01DKA019n	48.65	48.75	East Meaford Creek	grey shale	s19	G	x
01DKA019o	53.80	54.00	East Meaford Creek	grey shale	s20	G	x
01DKA019p	60.30	60.40	East Meaford Creek	hard, dark green shale	s23	G	x
01DKA019q	62.35	62.55	East Meaford Creek	grey shale	s24	G	x
01DKA019r	63.90	64.10	East Meaford Creek	grey shale	s24	G	x
01DKA019s	66.40	66.60	East Meaford Creek	grey shale	s25	G	x
01DKA019t	67.15	67.20	East Meaford Creek	grey, laminated limestone	s25	G	x
01DKA019u	67.55	67.65	East Meaford Creek	medium- to coarse-grained bioclastic limestone	s25	G	
01DKA019v	71.65	72.05	East Meaford Creek	grey shale	s26	G	x
01DKA019w	75.85	76.05	East Meaford Creek	grey shale	s28	G	x
01DKA019x	80.25	80.55	East Meaford Creek	grey shale	s30	G	x
01DKA019y	83.80	84.00	East Meaford Creek	grey shale	s31	G	x
01DKA019z	85.60	85.80	East Meaford Creek	grey shale	s32	G	x
01DKA019aa	90.95	91.05	East Meaford Creek	grey shale	s34	G	x
01DKA019ab	93.15	93.25	East Meaford Creek	green-grey shale	s36	G	x
01DKA019ac	95.60	95.80	East Meaford Creek	grey shale	s37	G	x
01DKA019ad	97.30	97.50	East Meaford Creek	grey shale	s37	G	x

Sample #	Elevation (m)		Location Name	Sample Description	Lithologic Unit or Section (s) #	Formation	Analyzed
	from	to					
01DKA019ae	98.20	98.40	East Meaford Creek	grey shale with minor limestone	s37	G	x
01DKA020a	-0.07	0.00	Russell Quarry	red calcisiltite, rippled top; quarry floor	1	Q	
01DKA020b	1.80	1.85	Russell Quarry	hard, red shale	2	Q	
01DKA020c	3.55	3.60	Russell Quarry	laminated limestone	4	Q	
01DKA020d	7.95	8.05	Russell Quarry	red shale with small green mottles	4	Q	x
01DKA020e	9.10	9.15	Russell Quarry	green calcisiltite (limestone)	5	Q	
01DKA020f	11.90	11.95	Russell Quarry	red silty shale, with evaporite(?) casts	6	Q	
01DKA022a	0.00	0.05	Sucker Creek	grey shale	s1	G	x
01DKA022b	0.90	0.95	Sucker Creek	limestone	s1	G	x
01DKA022c	4.45	4.55	Sucker Creek	grey shale	s3	G	x
01DKA022d	6.00	6.05	Sucker Creek	medium- to coarse-grained, bioclastic limestone	s3	G	
01DKA022e	9.75	9.85	Sucker Creek	grey till (Quaternary)	s6	n/a	
01DKA022f	11.50	11.60	Sucker Creek	grey shale	s8	G	x
01DKA022g	14.40	14.80	Sucker Creek	indurated, light grey clay-sand till (Quaternary)	s9	n/a	
01DKA022h	16.80	16.90	Sucker Creek	grey shale	s11	G	x
01DKA022i	19.10	19.30	Sucker Creek	grey shale	s12	G	x
01DKA022j	23.00	23.20	Sucker Creek	grey shale with limestone	s15	G	x
01DKA022k	23.50	23.55	Sucker Creek	bioclastic limestone with barite(?)	s15	G	
01DKA022l	27.45	27.50	Sucker Creek	grey shale	s17	G	x
01DKA022m	32.50	32.70	Sucker Creek	grey shale	s17	G	x
01DKA022n	35.40	35.50	Sucker Creek	grey shale	s20	G	x
01DKA024a	0.30	0.40	Christie Beach Creek	grey shale	s1	B	x
01DKA024b	3.85	4.05	Christie Beach Creek	grey shale	s3	B	x
01DKA024c	5.00	5.40	Christie Beach Creek	grey shale	s4	B	x

Sample #	Elevation (m)		Location Name	Sample Description	Lithologic Unit or Section (s) #	Formation	Analyzed
	from	to					
01DKA024d	4.60	4.70	Christie Beach Creek	thin, laminated, fine-grained, grey limestone	s5	B	x
01DKA024e	5.80	6.20	Christie Beach Creek	grey shale	s9	B	x
01DKA024f	18.20	18.40	Christie Beach Creek	grey shale, with minor crinoids	s11	B	x
01DKA024g	18.95	19.00	Christie Beach Creek	grey, laminated limestone	s11	B	
01DKA024h	20.85	21.15	Christie Beach Creek	grey shale	s13	B	x
01DKA024i	22.90	23.10	Christie Beach Creek	grey shale with minor limestone	s13	B	x
01DKA024j	25.65	25.85	Christie Beach Creek	laminated limestone	s13	B	x
01DKA024k	27.90	28.10	Christie Beach Creek	grey shale	s13	B	x
01DKA024l	31.95	32.05	Christie Beach Creek	grey shale	s15	B	x
01DKA024m	34.05	34.85	Christie Beach Creek	grey shale	s15	B	x
01DKA025a	2.50	2.75	Loree, Thornbury	red shale	1	Q	x
01DKA025b	5.00	5.20	Loree, Thornbury	red shale, with minor green shale	1	Q	x
01DKA025c	18.00	18.20	Loree, Thornbury	red clayey shale, with 10% green shale	4	Q	x
01DKA025d	18.50	18.55	Loree, Thornbury	limestone	4	Q	x
01DKA025e	19.80	20.00	Loree, Thornbury	red shale	4	Q	x
01DKA026a	1.30	1.50	Silcote	red shale	2	Q	x
01DKA026b	2.30	2.50	Silcote	red shale, with minor green mottles	2	Q	x
01DKA027a	0.40	0.60	Silcote	red shale	1	Q	x
01DKA027b	1.00	1.10	Silcote	green limestone	2	Q	x
01DKA027c	1.45	1.85	Silcote	red shale	3	Q	x
01DKA027d	2.90	3.00	Silcote	green shale	4	Q	x
01DKA027e	3.40	3.45	Silcote	limestone	4	Q	x
01DKA028a	0.45	0.55	south of Christie Beach	red shale, with very minor green mottles	1	Q	x
01DKA028b	0.90	1.10	south of Christie Beach	red shale	1	Q	x

Sample #	Elevation (m)		Location Name	Sample Description	Lithologic Unit or Section (s) #	Formation	Analyzed
	from	to					
01DKA028c	1.65	1.85	south of Christie Beach	red shale, with very minor green mottles	1	Q	x
01DKA028d	1.50	1.53	south of Christie Beach	green, laminated calcisiltite, with green shale	1	Q	x
01DKA029a	0.15	0.25	southeast of Meaford	red (50%) and green (50%) shale	1	Q	x
01DKA029b	1.95	2.15	southeast of Meaford	red (40%) and green (60%) shale	1	Q	x
01DKA029c	2.55	2.65	southeast of Meaford	red shale, with minor green shale	1	Q	x
01DKA029d	1.90	1.92	southeast of Meaford	thin, red and green calcisiltite(?)	1	Q	x
00DKA021a	0.40	0.50	Inglis Falls road cut, Owen Sound	non-calcareous green shale; 0.4 to 0.5 m below top contact of formation	1	C	x
00DKA022a	0.00	0.10	Dodd's Hill (Big Bay) road cut	red shale in ditch at base of outcrop	1	C	x
00DKA022b	1.50	1.60	Dodd's Hill (Big Bay) road cut	green shale + approx. 3 cm red shale	1	C	x
00DKA022c	3.00	3.10	Dodd's Hill (Big Bay) road cut	red shale	1	C	x
00DKA023b	0.20	0.30	Lion's Head beach	green non-calcareous shale; 0.3 to 0.4 cm below top contact of formation	1	W	x
00DKA024a	0.00	0.10	Rush Cove	red shale with 2 green mottles, non-calcareous	1	C	x
00DKA024b	1.00	1.10	Rush Cove	green shale: blocky, non-calcareous	1	C	x

Appendix 4

Major and minor element data for field composite samples (*from* Armstrong and Sergerie 2002a)

Appendix 4: Major and minor element data for field composite samples (see Appendix 2 for sample locations and descriptions; double lines separate samples from different stations; analytical detection limits and units listed at the end of the table).

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
01DKA110a	58.65	15.02	0.09	2.77	3.72	0.51	4.47	0.14	0.80	6.11	6.81	99.08	3.01	n.d.
01DKA111a	49.12	15.62	0.08	4.38	7.72	0.12	4.78	0.13	0.72	5.00	11.45	99.12	7.61	0.18
01DKA111b	49.25	15.72	0.08	4.18	7.61	0.12	4.75	0.13	0.71	6.19	11.40	100.15	7.30	0.07
01DKA111c	41.76	13.40	0.09	3.69	14.35	0.12	3.75	0.13	0.59	5.45	16.29	99.64	13.70	0.02
01DKA111d	42.46	13.79	0.09	3.83	13.57	0.10	3.90	0.13	0.60	5.61	15.76	99.82	12.10	0.02
01DKA111e	39.07	11.02	0.09	3.41	18.17	0.13	3.81	0.13	0.52	4.21	18.73	99.29	15.60	0.02
01DKA111f	45.66	14.26	0.08	3.75	11.03	0.12	4.21	0.12	0.64	6.34	13.71	99.94	9.94	0.01
01DKA111g	41.58	12.83	0.09	3.72	14.96	0.13	3.66	0.14	0.57	5.15	16.73	99.56	13.20	0.01
01DKA111h	43.22	13.71	0.08	3.79	12.88	0.14	3.93	0.13	0.61	6.12	15.18	99.78	11.50	0.01
01DKA111i	40.24	11.49	0.09	3.69	16.48	0.13	3.99	0.14	0.55	4.68	17.57	99.05	14.40	0.01
01DKA111j	43.81	13.69	0.09	3.95	12.76	0.14	3.97	0.13	0.61	5.40	15.20	99.75	11.60	0.01
01DKA111k	37.43	11.17	0.09	3.61	18.16	0.17	3.82	0.13	0.50	4.95	18.98	99.01	15.80	0.01
01DKA111l	42.19	13.14	0.09	3.93	13.80	0.14	3.75	0.13	0.58	5.70	16.05	99.50	12.60	0.01
01DKA111m	41.28	12.25	0.09	3.58	15.01	0.20	4.10	0.14	0.56	5.52	16.51	99.24	13.20	0.01
01DKA111n	41.34	13.46	0.09	3.44	14.43	0.16	3.86	0.15	0.57	5.38	16.01	98.88	12.60	0.01
01DKA111o	38.93	11.00	0.10	3.12	18.40	0.18	3.75	0.13	0.52	4.56	18.57	99.25	15.50	0.01
01DKA111p	44.65	13.24	0.08	3.20	12.31	0.12	3.82	0.12	0.59	5.70	14.02	97.86	10.70	0.46
01DKA111q	42.59	13.91	0.09	3.54	13.73	0.15	3.95	0.14	0.59	5.51	15.55	99.76	12.10	0.02
01DKA111r	46.52	15.36	0.08	3.83	9.63	0.15	4.54	0.15	0.66	6.66	12.67	100.25	8.73	0.01
01DKA111s	44.30	13.61	0.09	3.83	13.13	0.15	4.00	0.15	0.62	4.94	15.17	100.00	12.00	0.02
01DKA111t	44.18	14.02	0.09	4.14	12.21	0.19	4.07	0.15	0.63	5.48	14.82	99.98	11.50	0.01
01DKA111u	39.94	11.98	0.10	4.05	16.15	0.20	3.99	0.14	0.54	5.39	17.77	100.25	14.40	0.02
01DKA111v	40.77	13.44	0.09	3.83	14.52	0.16	3.83	0.13	0.57	5.38	16.63	99.36	13.10	0.02
01DKA111w	35.68	10.75	0.10	3.53	19.96	0.19	3.64	0.14	0.47	4.74	20.20	99.39	17.10	0.03
01DKA111x	34.21	9.57	0.11	3.33	22.86	0.19	3.36	0.13	0.42	3.35	22.04	99.58	19.10	0.03
01DKA111y	44.30	14.40	0.08	3.79	11.32	0.19	4.27	0.13	0.63	6.41	13.97	99.49	10.20	0.02
01DKA111z	35.04	11.39	0.10	2.96	20.26	0.26	3.77	0.13	0.45	5.32	19.88	99.57	17.10	0.03
01DKA111aa	36.87	11.31	0.10	3.37	19.02	0.25	3.76	0.13	0.48	4.09	19.32	98.71	15.90	0.16
01DKA111ab	33.53	10.19	0.11	3.30	22.42	0.25	3.32	0.13	0.43	4.24	21.71	99.62	18.70	0.10
01DKA111ac	34.62	10.28	0.10	3.72	18.52	0.19	3.45	0.11	0.44	3.91	18.64	93.98	14.60	1.58

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
01DKA111ad	41.45	13.86	0.10	4.53	12.24	0.16	3.93	0.12	0.58	6.27	14.68	97.92	10.20	1.10
01DKA111ae	32.36	10.36	0.11	4.07	19.86	0.21	3.34	0.10	0.42	4.85	19.59	95.28	14.50	1.91
01DKA111af	37.17	11.25	0.10	4.23	17.16	0.17	3.84	0.12	0.49	5.20	18.52	98.25	15.00	0.44
01DKA111ag	43.65	12.51	0.10	4.78	12.21	0.14	3.92	0.13	0.58	5.85	15.15	99.03	11.50	0.51
01DKA111ah	38.59	11.04	0.12	5.81	15.30	0.23	3.64	0.12	0.51	4.35	18.34	98.04	14.90	0.68
01DKA111ai	40.67	12.45	0.11	5.54	13.20	0.23	3.64	0.13	0.57	5.28	16.97	98.78	13.30	0.36
01DKA111aj	39.70	9.87	0.11	5.68	15.22	0.21	3.52	0.14	0.51	4.60	18.45	98.00	14.90	0.78
01DKA111ak	43.45	11.41	0.12	6.53	11.90	0.21	3.59	0.13	0.61	4.89	16.66	99.50	13.70	0.26
01DKA111al	45.70	12.09	0.10	5.88	10.05	0.24	3.78	0.13	0.64	5.42	14.23	98.27	10.10	1.06
01DKA111am	44.09	12.86	0.11	5.41	11.69	0.21	3.76	0.14	0.61	5.53	15.36	99.77	11.90	0.34
01DKA111an	43.10	11.89	0.10	5.12	12.11	0.23	3.54	0.12	0.58	4.89	15.21	96.90	10.80	1.33
01DKA111ao	43.66	11.66	0.11	5.26	12.32	0.22	3.52	0.15	0.60	5.18	15.85	98.51	12.30	0.47
01DKA111ap	43.27	12.49	0.10	4.42	12.60	0.17	3.63	0.13	0.59	5.59	14.93	97.91	10.70	1.06
01DKA111aq	42.46	11.90	0.11	4.88	14.05	0.21	3.29	0.13	0.59	4.64	16.61	98.88	13.30	0.54
01DKA111ar	37.16	9.61	0.09	3.68	15.43	0.19	3.21	0.10	0.48	4.66	15.51	90.12	8.58	3.63
01DKA111as	47.23	13.02	0.10	4.31	10.67	0.22	3.91	0.14	0.66	5.76	13.58	99.60	10.20	0.18
01DKA111at	43.90	11.82	0.11	4.01	14.29	0.17	3.36	0.14	0.63	4.90	16.19	99.50	13.10	0.09
01DKA111au	47.90	13.58	0.09	3.80	10.35	0.25	4.02	0.13	0.67	6.34	13.03	100.14	9.24	0.14
01DKA111av	48.63	13.97	0.09	3.46	10.20	0.19	4.19	0.14	0.68	6.43	12.44	100.42	8.72	0.04
01DKA111aw	48.46	12.51	0.11	3.11	12.13	0.21	3.67	0.13	0.63	4.97	13.50	99.41	10.50	0.06
01DKA111ax	39.97	9.83	0.15	3.10	19.10	0.25	3.27	0.12	0.50	4.05	18.99	99.34	16.10	0.02
01DKA111ay	53.16	13.83	0.09	3.55	7.72	0.24	4.24	0.15	0.76	6.20	10.43	100.38	7.14	0.02
01DKA111az	42.79	10.17	0.13	3.90	15.92	0.27	3.50	0.13	0.53	4.35	17.46	99.15	14.60	0.03
01DKA111ba	52.66	13.81	0.10	4.42	7.27	0.22	4.35	0.15	0.71	5.88	11.22	100.78	7.85	0.02
01DKA111bb	32.47	8.85	0.14	4.72	23.08	0.29	2.79	0.10	0.41	3.78	23.26	99.88	20.80	0.26
01DKA120a	60.04	10.31	0.24	1.91	9.93	1.62	1.83	0.13	0.61	3.36	9.95	99.95	8.08	0.01
01DKA120b	59.15	15.53	0.09	2.92	3.63	1.15	3.75	0.14	0.79	6.96	6.52	100.63	2.98	0.01
01DKA120c	54.63	11.30	0.36	2.08	12.21	1.38	2.15	0.13	0.61	2.96	12.12	99.93	9.72	0.02
01DKA120d	59.94	15.84	0.11	2.81	2.86	1.12	3.85	0.14	0.80	6.91	6.09	100.48	2.30	0.01
01DKA120e	59.55	14.25	0.13	2.66	5.74	1.26	3.25	0.15	0.76	4.76	7.77	100.27	4.71	0.02
01DKA120f	58.99	15.00	0.11	2.71	4.47	1.15	3.54	0.14	0.76	6.18	7.06	100.11	3.63	0.01
detection limits	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	n/a	0.03	0.01
units	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%

Appendix 5

Major and minor element data for field bed samples (from Armstrong and Sergerie 2002a)

Appendix 5: Major and minor element data for field bed samples (see Appendix 3 for sample locations and descriptions; double lines separate samples from different stations; analytical detection limits and units listed at the end of the table).

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
01DKA001a	56.39	17.76	0.08	3.49	1.92	0.70	4.59	0.25	0.92	7.76	6.15	100.03	2.12	0.30
01DKA002a	56.68	16.72	0.10	3.58	2.70	0.75	4.38	0.21	0.89	7.33	6.58	99.92	2.88	0.23
01DKA002c	63.27	16.11	0.09	2.79	0.59	1.04	4.21	0.19	0.96	6.43	4.88	100.57	0.67	0.02
01DKA003a	56.41	16.00	0.10	3.56	3.52	0.74	4.25	0.17	0.86	7.02	7.40	100.03	3.42	0.04
01DKA003d	59.10	8.85	0.21	2.60	9.21	1.22	1.84	0.14	0.54	6.20	9.01	98.90	8.34	1.29
01DKA003e	57.35	17.15	0.08	3.18	2.35	0.64	4.65	0.16	0.92	7.06	6.81	100.36	1.96	0.02
01DKA004a	45.80	5.54	0.24	2.12	21.45	1.08	1.09	0.10	0.32	2.71	19.52	99.97	17.20	0.03
01DKA004d	55.76	16.68	0.11	3.90	2.77	0.65	4.68	0.18	0.86	6.98	7.54	100.10	3.31	0.03
01DKA007a	56.83	17.61	0.13	3.30	2.46	0.74	4.42	0.17	0.89	6.64	6.86	100.05	3.23	0.22
01DKA007b	54.72	17.54	0.10	3.10	2.38	0.68	4.41	0.23	0.80	7.60	7.81	99.36	7.22	1.40
01DKA007c	54.93	17.32	0.15	3.24	3.55	0.77	4.29	0.22	0.86	6.66	7.78	99.77	4.65	0.36
01DKA007d	54.97	17.62	0.10	3.07	2.13	0.67	4.45	0.20	0.82	7.92	7.50	99.45	5.96	1.49
01DKA008a	64.79	9.41	0.20	3.06	5.41	1.38	2.04	0.14	0.59	4.58	8.15	99.74	6.53	0.14
01DKA008b	56.94	17.68	0.07	3.43	1.32	0.70	4.72	0.21	0.96	7.30	5.96	99.29	1.63	0.42
01DKA008e	64.34	10.98	0.16	2.65	5.06	1.43	2.38	0.17	0.73	5.07	7.30	100.26	5.04	0.12
01DKA008f	63.16	13.51	0.09	2.80	2.66	1.34	3.25	0.18	0.84	6.04	5.56	99.45	2.91	0.28
01DKA008g	63.71	11.60	0.15	2.73	4.51	1.50	2.58	0.17	0.76	5.29	7.08	100.08	4.68	0.06
01DKA008h	63.83	11.33	0.16	2.79	4.91	1.49	2.50	0.14	0.67	4.81	7.52	100.16	5.27	0.03
01DKA009a	50.82	14.15	0.09	2.85	10.12	0.29	3.98	0.15	0.71	5.47	11.80	100.44	7.79	0.01
01DKA009b	46.32	10.53	0.10	2.27	16.28	0.51	3.32	0.15	0.58	3.26	15.88	99.20	12.50	0.02
01DKA009c	57.33	15.41	0.08	2.96	4.12	0.39	4.58	0.15	0.83	7.07	7.37	100.29	3.28	0.01
01DKA009d	51.65	15.21	0.10	3.32	7.04	0.17	4.51	0.14	0.74	6.53	10.24	99.64	5.83	0.01
01DKA009e	55.67	15.98	0.08	3.33	4.08	0.19	4.82	0.14	0.81	7.14	8.04	100.27	3.47	0.01
01DKA009f	52.10	15.90	0.09	3.39	6.24	0.12	4.72	0.14	0.75	7.16	9.78	100.40	5.29	0.01
01DKA010a	57.64	15.82	0.09	2.95	3.59	0.34	4.63	0.14	0.81	6.99	7.13	100.13	2.95	0.01
01DKA010b	59.42	12.79	0.13	2.52	7.19	0.79	3.45	0.15	0.79	3.46	9.06	99.76	6.07	0.01

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
01DKA010c	57.93	14.42	0.12	2.81	5.52	0.45	4.11	0.15	0.81	5.70	8.18	100.19	4.48	n.d.
01DKA010d	57.39	15.96	0.09	3.04	3.62	0.27	4.75	0.14	0.82	6.85	7.06	100.00	2.93	n.d.
01DKA013a	55.83	16.68	0.09	3.02	3.32	0.59	4.31	0.18	0.88	7.11	7.73	99.74	2.80	0.02
01DKA013b	55.33	17.11	0.11	3.03	3.32	0.53	4.62	0.22	0.89	7.34	7.46	99.96	2.67	0.01
01DKA013c	51.57	7.71	0.24	1.31	16.50	1.12	1.85	0.14	0.48	4.28	14.59	99.78	12.30	0.10
01DKA013d	58.14	17.29	0.08	3.07	2.15	0.55	4.65	0.19	0.92	6.95	6.57	100.55	1.82	0.01
01DKA014a	52.47	14.47	0.11	2.83	7.91	0.18	4.15	0.14	0.73	6.68	10.32	99.99	6.24	0.01
01DKA014b	49.20	13.77	0.11	3.21	10.27	0.18	3.90	0.14	0.69	6.32	12.47	100.27	8.36	0.01
01DKA014c	50.72	8.04	0.13	2.00	16.69	0.72	2.39	0.13	0.47	2.82	15.54	99.64	12.90	0.02
01DKA014d	54.27	14.57	0.08	3.03	6.31	0.22	4.34	0.14	0.76	7.29	9.11	100.12	5.05	0.01
01DKA014f	49.10	14.90	0.09	3.26	7.57	0.06	4.33	0.12	0.70	8.04	12.71	100.90	5.70	n.d.
01DKA014g	51.58	15.08	0.09	3.01	6.07	0.09	4.59	0.13	0.74	8.03	10.64	100.03	4.49	n.d.
01DKA014h	50.01	12.99	0.11	2.98	10.58	0.27	3.68	0.14	0.69	5.28	13.31	100.04	8.36	n.d.
01DKA014i	54.78	10.31	0.12	2.18	12.46	0.84	2.71	0.13	0.55	3.21	12.95	100.23	9.53	n.d.
01DKA015a	46.74	14.08	0.10	3.08	11.98	0.10	3.98	0.13	0.64	5.73	13.77	100.33	9.66	0.01
01DKA015b	35.26	7.99	0.13	2.25	24.67	0.16	2.85	0.16	0.45	2.62	22.40	98.93	18.60	0.02
01DKA015c	49.05	15.00	0.09	3.35	8.59	0.11	4.41	0.14	0.70	7.29	11.59	100.31	7.12	0.01
01DKA015d	50.99	15.65	0.08	3.13	7.13	0.11	4.68	0.13	0.74	7.39	10.16	100.19	5.73	0.01
01DKA015e	39.78	10.92	0.10	2.68	19.12	0.17	3.60	0.13	0.53	3.44	18.73	99.20	14.80	0.02
01DKA015g	47.95	14.99	0.09	3.69	8.75	0.11	4.41	0.13	0.69	7.04	12.08	99.93	7.61	0.01
01DKA015h	50.35	16.01	0.08	3.50	6.69	0.12	4.77	0.13	0.74	7.49	10.27	100.15	5.75	0.01
01DKA016a	47.23	11.08	0.12	3.68	13.37	0.29	3.23	0.16	0.67	4.81	15.22	99.85	11.70	0.01
01DKA016b	39.51	12.13	0.10	3.43	16.00	0.18	3.96	0.13	0.53	5.52	17.39	98.89	13.10	0.01
01DKA016c	43.71	13.88	0.10	4.06	12.13	0.11	3.99	0.13	0.61	6.07	15.00	99.78	10.70	0.01
01DKA016d	41.95	7.41	0.12	3.03	21.07	0.40	2.73	0.13	0.45	2.33	20.06	99.67	17.20	0.02
01DKA016e	41.14	11.73	0.09	2.93	15.89	0.13	4.01	0.13	0.55	5.70	16.57	98.88	12.60	0.02
01DKA016f	35.66	9.10	0.11	2.71	23.20	0.12	3.20	0.13	0.43	3.50	21.68	99.85	19.40	0.02
01DKA016g	36.53	11.65	0.10	2.83	18.84	0.15	3.90	0.13	0.48	5.54	18.81	98.96	14.60	0.02

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
01DKA016h	33.03	9.00	0.12	2.84	24.84	0.14	3.06	0.13	0.40	2.99	23.11	99.67	19.20	0.03
01DKA016i	42.54	13.80	0.09	3.05	14.00	0.10	3.77	0.14	0.59	5.80	15.57	99.45	11.30	0.01
01DKA017a	47.07	14.83	0.08	3.47	9.93	0.10	4.30	0.13	0.66	7.02	12.50	100.10	8.31	0.01
01DKA017b	45.39	14.48	0.10	3.06	11.84	0.09	4.15	0.12	0.63	6.27	13.67	99.81	9.39	0.01
01DKA017c	43.06	12.99	0.09	3.03	14.88	0.09	3.57	0.12	0.60	5.05	16.08	99.56	12.00	0.01
01DKA017d	43.08	13.57	0.09	3.23	13.53	0.09	3.81	0.13	0.61	5.73	15.14	99.01	11.00	0.01
01DKA017e	50.41	14.24	0.09	4.13	9.18	0.10	4.36	0.13	0.72	4.23	12.45	100.03	8.57	0.01
01DKA017f	43.50	13.45	0.10	3.42	13.62	0.08	3.75	0.14	0.61	5.36	15.39	99.41	11.20	0.01
01DKA017g	46.14	14.41	0.10	4.07	11.27	0.08	4.16	0.13	0.65	4.48	14.22	99.70	10.40	0.01
01DKA018a	53.23	10.51	0.23	4.01	9.02	0.88	2.61	0.14	0.64	5.98	11.82	99.07	10.40	0.61
01DKA018b	12.04	3.79	0.61	7.26	32.37	0.17	1.01	0.10	0.16	7.15	34.16	98.83	40.40	1.00
01DKA018c	57.64	13.92	0.12	3.17	5.24	0.79	3.76	0.16	0.79	5.88	7.95	99.43	5.57	0.47
01DKA018d	57.99	17.29	0.06	3.36	1.65	0.49	4.94	0.14	0.87	6.94	5.89	99.62	2.61	0.85
01DKA018e	57.81	16.52	0.07	3.23	1.97	0.59	4.70	0.15	0.89	6.78	6.19	98.90	3.12	0.87
01DKA018g	56.80	16.60	0.08	3.35	2.59	0.57	4.76	0.19	0.89	6.72	6.52	99.08	3.14	0.61
01DKA018h	57.77	18.05	0.07	3.56	1.42	0.40	5.21	0.16	0.90	6.61	6.11	100.25	2.32	0.28
01DKA018i	59.21	15.90	0.08	3.27	2.72	0.70	4.53	0.17	0.88	6.31	6.19	99.97	3.36	0.56
01DKA018j	57.97	15.62	0.09	3.23	3.85	0.72	4.30	0.17	0.86	6.35	6.96	100.13	4.20	0.60
01DKA019a	59.21	16.36	0.07	3.21	2.11	0.63	4.71	0.15	0.90	6.42	5.84	99.61	2.76	0.69
01DKA019b	59.06	16.54	0.07	3.33	1.98	0.60	4.86	0.15	0.84	6.54	6.17	100.13	2.86	0.74
01DKA019c	60.42	16.28	0.07	3.19	2.16	0.68	4.63	0.18	0.87	6.04	5.85	100.35	2.71	0.37
01DKA019d	25.80	5.73	0.27	2.98	30.39	0.52	1.63	0.10	0.29	4.00	27.38	99.08	25.80	0.38
01DKA019e	57.80	10.01	0.22	3.83	7.93	1.06	2.59	0.16	0.68	5.01	10.97	100.26	9.52	0.25
01DKA019f	59.11	17.03	0.07	3.28	1.53	0.61	4.89	0.17	0.92	6.60	5.61	99.82	2.26	0.53
01DKA019g	57.66	17.76	0.07	3.47	1.61	0.44	5.14	0.17	0.89	6.84	6.09	100.15	2.39	0.59
01DKA019h	56.72	18.22	0.08	3.55	1.96	0.38	5.21	0.19	0.92	6.79	6.28	100.30	2.52	0.27
01DKA019i	61.53	15.62	0.07	3.00	2.52	0.85	4.33	0.18	0.90	6.16	5.76	100.93	2.89	0.57
01DKA019j	58.95	17.16	0.07	3.31	2.14	0.60	4.85	0.18	0.93	6.57	6.05	100.82	2.64	0.41

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
01DKA019l	58.88	16.30	0.08	3.29	2.64	0.69	4.54	0.17	0.88	6.46	6.21	100.15	3.11	0.40
01DKA019m	58.18	17.18	0.07	3.41	2.18	0.54	4.83	0.18	0.90	6.86	6.06	100.40	2.76	0.52
01DKA019n	59.38	16.59	0.07	3.18	2.07	0.68	4.63	0.18	0.91	6.73	5.79	100.21	2.49	0.66
01DKA019o	58.60	16.48	0.08	3.26	2.61	0.65	4.64	0.18	0.90	6.57	6.13	100.09	2.93	0.43
01DKA019p	56.73	17.84	0.09	3.63	2.32	0.35	5.16	0.22	0.91	7.04	6.66	100.96	2.56	0.13
01DKA019q	60.50	15.84	0.08	3.20	2.69	0.75	4.53	0.18	0.89	6.03	5.99	100.67	3.04	0.34
01DKA019r	59.13	16.01	0.09	3.38	2.75	0.70	4.62	0.20	0.90	6.39	6.28	100.44	3.23	0.38
01DKA019s	59.82	15.62	0.08	3.33	2.18	0.78	4.65	0.18	0.89	6.41	5.73	99.66	2.49	0.37
01DKA019t	57.32	6.67	0.22	3.46	11.63	1.05	1.90	0.18	0.51	3.90	13.21	100.06	11.50	0.13
01DKA019v	52.78	16.14	0.14	4.17	4.47	0.33	4.81	0.24	0.82	7.16	8.76	99.81	4.99	0.20
01DKA019w	55.10	16.45	0.11	3.88	3.12	0.35	4.93	0.22	0.86	7.30	7.23	99.58	3.57	0.41
01DKA019x	57.25	18.17	0.07	3.63	1.25	0.25	5.59	0.20	0.94	7.07	5.99	100.41	1.27	0.09
01DKA019y	55.14	17.21	0.11	4.00	2.67	0.30	5.23	0.23	0.87	7.27	7.17	100.20	3.11	0.17
01DKA019z	61.31	15.20	0.07	3.16	2.21	0.76	4.92	0.20	0.78	6.21	5.43	100.26	2.35	0.52
01DKA019aa	58.37	17.01	0.08	3.59	2.00	0.45	5.20	0.21	0.90	6.75	6.01	100.57	2.05	0.12
01DKA019ab	57.28	15.70	0.11	3.68	3.28	0.52	4.77	0.24	0.88	6.69	7.04	100.20	3.44	0.15
01DKA019ac	56.14	14.83	0.13	3.86	4.33	0.58	4.46	0.23	0.77	6.65	8.15	100.12	4.78	0.18
01DKA019ad	57.93	16.90	0.09	3.36	2.13	0.50	5.10	0.17	0.89	6.79	6.25	100.10	2.05	0.03
01DKA019ae	49.78	15.02	0.11	2.83	9.28	0.42	4.14	0.19	0.75	6.31	11.30	100.14	7.23	0.11
01DKA020d	58.01	15.83	0.10	2.92	4.47	1.04	3.75	0.14	0.76	6.61	7.21	100.84	3.61	0.02
01DKA022a	58.49	16.54	0.08	3.41	2.51	0.48	4.79	0.18	0.91	6.49	6.37	100.25	3.29	0.39
01DKA022b	50.78	7.20	0.17	2.40	15.70	0.92	2.21	0.14	0.49	3.84	15.10	98.95	13.60	0.19
01DKA022c	56.30	17.49	0.08	3.46	2.73	0.32	5.13	0.20	0.90	7.12	6.52	100.24	3.08	0.90
01DKA022f	57.05	17.42	0.08	3.65	2.46	0.31	5.16	0.21	0.89	6.68	6.77	100.69	2.93	0.28
01DKA022h	54.38	17.57	0.10	4.01	2.98	0.18	5.22	0.24	0.86	7.55	7.30	100.38	3.67	0.57
01DKA022i	56.17	17.46	0.09	3.81	2.59	0.21	5.19	0.23	0.88	7.27	6.67	100.57	3.11	0.48
01DKA022j	54.90	13.43	0.11	3.16	6.96	0.46	4.06	0.17	0.71	5.49	9.23	98.68	6.71	0.24
01DKA022l	59.29	18.00	0.05	3.14	1.32	0.48	6.90	0.16	0.65	5.32	5.29	100.58	1.56	0.34

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
01DKA022m	61.00	17.36	0.07	3.28	0.65	0.31	5.57	0.22	0.95	6.24	5.03	100.69	0.96	0.02
01DKA022n	57.64	17.15	0.08	3.63	1.98	0.25	5.37	0.27	0.87	6.92	6.08	100.23	2.21	0.33
01DKA024a	54.20	17.84	0.10	3.67	3.07	0.33	4.96	0.19	0.85	7.12	7.56	99.88	4.36	0.88
01DKA024b	57.91	17.54	0.08	3.43	2.05	0.48	4.89	0.14	0.85	6.58	6.12	100.06	2.74	0.68
01DKA024c	55.78	18.17	0.08	3.46	2.13	0.36	5.06	0.16	0.86	7.32	6.58	99.95	3.44	1.08
01DKA024d	50.84	11.02	0.19	2.12	13.92	0.96	2.43	0.15	0.64	4.57	12.94	99.78	11.40	0.62
01DKA024e	56.16	17.88	0.08	3.54	2.09	0.43	5.12	0.18	0.86	6.90	6.50	99.75	2.66	0.60
01DKA024f	56.25	17.38	0.10	3.67	2.56	0.53	4.90	0.19	0.87	6.95	6.85	100.24	3.22	0.49
01DKA024h	58.58	16.06	0.08	3.17	2.71	0.78	4.44	0.16	0.85	6.65	6.37	99.84	3.32	0.83
01DKA024i	54.92	14.47	0.12	3.07	6.39	0.82	3.85	0.15	0.78	6.07	8.55	99.21	6.11	0.54
01DKA024j	61.13	10.62	0.13	2.76	6.30	1.26	2.71	0.15	0.67	5.52	7.82	99.08	6.29	1.01
01DKA024k	58.99	16.80	0.07	3.27	1.76	0.72	4.77	0.15	0.91	6.66	5.79	99.88	2.32	0.51
01DKA024l	58.56	17.29	0.07	3.40	1.58	0.64	4.86	0.17	0.90	6.95	5.79	100.21	2.18	0.46
01DKA024m	59.00	16.73	0.07	3.29	1.75	0.70	4.70	0.16	0.89	6.71	5.73	99.72	2.35	0.54
01DKA025a	41.13	14.15	0.09	3.14	14.02	0.15	3.90	0.13	0.57	6.40	15.84	99.52	10.80	0.02
01DKA025b	39.24	12.51	0.10	2.84	16.56	0.14	4.10	0.12	0.53	5.41	17.42	98.97	12.70	0.02
01DKA025c	42.17	12.05	0.09	3.09	15.12	0.15	3.97	0.13	0.58	5.34	16.34	99.02	11.70	0.01
01DKA025d	26.72	5.73	0.14	2.00	32.55	0.12	2.18	0.13	0.29	1.93	27.93	99.71	23.60	0.03
01DKA025e	39.78	12.55	0.09	2.98	15.68	0.18	4.06	0.15	0.53	6.07	16.81	98.87	12.00	0.01
01DKA026a	38.40	13.04	0.08	4.96	14.67	0.13	3.66	0.13	0.52	5.80	18.13	99.52	13.60	0.01
01DKA026b	37.52	12.03	0.08	5.05	15.44	0.16	3.99	0.14	0.50	5.36	18.69	98.96	14.00	0.01
01DKA027a	42.78	13.89	0.10	5.74	10.60	0.12	4.16	0.12	0.60	6.42	15.65	100.19	10.90	0.01
01DKA027b	34.28	11.02	0.13	7.92	15.83	0.18	3.56	0.11	0.47	4.22	21.72	99.45	17.00	0.02
01DKA027c	38.74	11.85	0.11	6.15	14.30	0.16	3.44	0.14	0.53	5.60	18.72	99.74	14.30	0.02
01DKA027d	39.02	12.70	0.11	7.59	12.34	0.11	3.85	0.12	0.55	4.84	18.55	99.79	14.10	0.05
01DKA027e	37.30	7.28	0.12	7.54	18.81	0.14	2.79	0.16	0.37	3.07	22.94	100.52	19.30	0.02
01DKA028a	44.58	14.74	0.09	4.24	10.75	0.16	4.33	0.14	0.65	6.28	14.06	100.01	9.48	0.01
01DKA028b	47.28	16.32	0.08	4.19	7.76	0.16	4.81	0.14	0.69	7.38	11.73	100.53	7.00	0.01

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
01DKA028c	44.87	15.13	0.08	3.94	10.63	0.19	4.31	0.14	0.64	6.70	13.65	100.28	9.00	0.01
01DKA028d	20.02	6.04	0.12	2.95	35.14	0.13	1.99	0.17	0.24	1.95	31.05	99.80	26.10	0.04
01DKA029a	37.30	11.46	0.11	5.80	15.63	0.15	3.75	0.13	0.50	4.58	19.77	99.18	15.10	0.02
01DKA029b	37.43	11.85	0.12	7.08	14.28	0.13	3.47	0.13	0.51	4.54	20.03	99.58	15.20	0.02
01DKA029c	39.10	12.89	0.12	6.62	12.37	0.12	3.80	0.15	0.54	6.17	18.06	99.95	13.20	0.02
01DKA029d	43.08	6.28	0.12	6.82	16.86	0.11	2.55	0.16	0.46	2.98	20.67	100.08	17.50	0.02
00DKA021a	52.36	16.93	0.05	4.21	3.21	0.20	5.93	0.12	0.76	6.06	9.21	99.03	4.68	1.24
00DKA022a	58.27	17.20	0.06	2.75	0.98	0.17	5.97	0.12	0.84	7.34	6.63	100.34	1.18	0.01
00DKA022b	55.53	15.20	0.05	4.25	4.06	0.18	5.21	0.22	0.65	5.01	10.11	100.47	5.50	0.01
00DKA022c	45.90	12.16	0.03	1.81	1.15	0.14	4.06	0.26	0.71	5.79	28.00	100.03	1.16	0.01
00DKA023b	30.44	9.20	0.03	12.44	15.13	0.16	3.27	0.04	0.39	2.63	25.94	99.69	23.10	0.13
00DKA024a	53.27	19.66	0.04	3.13	0.99	0.24	6.66	0.10	0.85	8.37	7.08	100.40	1.27	n.d.
00DKA024b	49.77	17.34	0.06	4.94	3.91	0.16	6.02	0.10	0.76	5.69	10.66	99.40	5.93	0.22
detection limits	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	n/a	0.03	0.01
units	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%

Appendix 6

2001 drill hole logs and geochemical data (*from* Armstrong and Sergerie 2002b)

Table 6-1: Drill hole locations and preliminary results of 2001 Ontario Geological Survey drill program.

Table 6-2: Lithologic log for drill hole OGS-01-01.

Table 6-3: Lithologic log for drill hole OGS-01-02.

Table 6-4: Lithologic log for drill hole OGS-01-03.

Table 6-5: Lithologic log for drill hole OGS-01-04.

Table 6-6: Lithologic log for drill hole OGS-01-05.

Table 6-7: Lithologic log for drill hole OGS-01-06.

Table 6-8a: Locations and descriptions of 2001 drill core bed samples.

Table 6-8b: Major and minor element data for 2001 drill core bed samples.

Table 6-9: Geochemical data and sample information for 2001 drill core composite samples.

Table 6-10: Trace and minor element data for drill core bed samples from OGS-01-06.

Table 6-11: Trace and minor element data for drill core bed samples from OGS-00-C1.

Table 6-1: Drill hole locations and preliminary results of 2001 Ontario Geological Survey drilling program (note: UTM coordinates in NAD 83; UTM locations in Grid Zone 17, except * in Grid Zone 16; all units in metres).

Hole #	Location	OGS Mapping Station #	UTM easting	UTM northing	NTS map #	Overburden Thickness	Total Depth Drilled	Bedrock Units (thickness)
OGS-01-01	northeast of Tullamore, northeast of Brampton: west side of Gore Way Drive, ~550 m south of Mayfield Road.	01DKA-030	598950	4850250	30M/13	1.50	32.00	Georgian Bay (30.50 m)
OGS-01-02	east of Rosemont, west of Alliston: west side of Concession 4 Road, ~1.2 km south of 30th Side Road, Adjala Twp.	01DKA-031	584657	4885765	31D/4	2.25	37.72	Georgian Bay (35.47 m)
OGS-01-03	east of Meaford: east side of Christie Beach Road, ~0.95 km north of Hwy. 26, ~250 m north of 39th Side Road, Collingwood Twp.	01DKA-032	538606	4937283	41A/10	1.60	44.12	Blue Mountain (42.52 m)
OGS-01-04	southeast of Meaford: on north side of 10th Side Road, < 250m east of 3rd Line Rd, ~2 km north of 7 Side Road, St. Vincent Twp.	01DKA-033	536270	4936455	41A/10	0.00	61.08	Queenston (13.82 m), Georgian Bay (47.26 m)
OGS-01-05	Balaclava, northwest of Meaford: on north side of 10th Side Road, < 250 m east of 3rd Line Rd, ~2 km north of 7 Side Road, Sydenham Twp.	01DKA-034	519274	4948872	41A/10	2.59	61.27	Queenston (2.09 m), Georgian Bay (56.59 m)
OGS-01-06	Russell Quarry, east of Ottawa, ~5 km north of Town of Russell.	01DKA-035	470909*	5016616*	31G/6	1.50	60.96	Queenston (21.45 m), Carlsbad (38.01 m)

Table 6-2: Lithologic log for drill hole OGS-01-01 (station 01DKA-030). "coarse beds" = non-shale interbeds; "OB" = overburden.

Top (m)	Bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
0.00	1.50	OB	n/a	clayey till, buff to tan in colour; abundant weathered clayey shale fragments at base.	
1.50	3.17	1	10	grey shale a with few limestone beds, up to 8 cm thick (averaging 5 cm); limestone is mainly fine- to medium-grained, with horizontal laminations and minor to no fossil content (mainly as thin basal lag deposits); fossiliferous shale interval at 2.70 to 2.75 m.	Georgian Bay Formation
3.17	6.40	2	0	mostly grey shale with no significant limestone beds.	
6.40	8.07	3	10	grey shale with limestone interbeds; limestone beds average 5 cm thick, and are mostly fine-grained and horizontally laminated, with local minor bioclastic intervals.	
8.07	9.85	4	<5	mostly grey shale with no significant limestone beds; shale is bioturbated at 9.40 to 9.85 m and minor >/=1 cm thick interbeds of rippled calcisiltite.	
9.85	14.51	5	20	grey shale with decimetric-scale limestone beds up to 20 cm thick (averaging 15 cm); bioturbated intervals in shale with some limestone lenses >1 cm thick; limestone is mainly fine- to medium-grained, with horizontal laminations (locally massive); minor bioclastic interval in one bed.	
14.51	17.85	6	0	mostly grey shale with intervals of hard, massive shale and no significant limestone beds.	
17.85	23.84	7	20	grey shale with limestone beds up to 23 cm thick (averaging 10 cm); limestone is mainly fine- to medium-grained, with horizontal and/or low angle laminations (locally massive); limestone bed near bottom of unit is bioturbated and massive; increase in carbonate content towards bottom of unit indicated by more calcareous shale and thinly interlaminated shale and limestone intervals between limestone beds.	
23.84	26.08	8	0	grey shale with some thinly interlaminated limestone; no significant limestone beds.	
26.08	28.22	9	10	grey shale with limestone beds up to 7 cm thick (averaging 5 cm); limestone is fine- to medium-grained, with horizontal and/or low angle laminations.	
28.22	32.00	10	35	grey shale with abundant limestone beds, up to 33 cm thick (averaging 12 cm); limestone is mainly fine- to medium-grained with horizontal and/or low angle laminations (locally massive); 10 cm bioclastic limestone bed at 30.09 to 30.19 m; 15 cm interval at 31.26 to 31.41 m is thinly interbedded hard shale and ripple-topped limestone.	

Table 6-3: Lithologic log for drill hole OGS-01-02 (station 01DKA-031). "coarse beds" = non-shale interbeds; "OB" = overburden.

Top (m)	Bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
0.00	2.25	OB	n/a	soil developed from 0 to 0.15 m; 0.15 to 2.25 m is tan/buff clay with a few granitic cobbles and limestone slabs and/or pebbles up to 1 cm; clay grades down into a green/grey colour with depth.	
2.25	7.29	1	<5	very rubbly shale becoming fissile in lower part of unit, with minor limestone beds averaging 5 cm thick; limestone beds concentrated at top of unit and are predominantly fine- to medium-grained and massive; buff colour (weathering) continues well down into unit.	Georgian Bay Formation
7.29	11.40	2	25	grey shale with significant limestone beds up to 15 cm thick (averaging 5 cm); limestone is mostly bioclastic, with small intervals of horizontally laminated calcisiltite.	
11.40	17.16	3	5	grey shale with </= 4 cm thick calcisiltite beds with horizontal to low angle laminations; some hard shale intervals.	
17.16	22.47	4	45	grey shale with relatively abundant limestone beds; limestone beds are up to 35 cm thick (averaging 8 cm); limestone is predominantly fine- to medium-grained with horizontal laminations and minor bioclastic and/or bioturbated parts; also some calcisiltite beds typically up to 4 cm thick (averaging 2 cm); local pyrite.	
22.47	27.44	5	10	grey shale with few limestone intervals up to 6 cm thick (averaging 3 cm); limestone is mainly fine- to medium-grained with horizontal laminations; 6 cm bioclastic interval within one bed; local gutter casts.	
27.44	32.59	6	30	grey shale with limestone beds up to 25 cm thick (averaging 10 cm); limestone is mainly fine- to medium-grained with horizontal laminations, bioclastic limestone in smaller beds or as thin intervals in larger beds; top bed is 25 cm thick and fines upward.	
32.59	35.14	7	10	grey shale with few thin calcisiltite beds up to 10 cm thick (averaging 3 cm); limestone is mainly fine- to medium-grained with horizontal laminations; limestone bed at 34.35 to 34.45 m is bioclastic and bioturbated.	
35.14	37.72	8	<5	grey shale with very thin calcisiltite beds.	

Table 6-4: Lithologic log for drill hole OGS-01-03 (station 01DKA-032). "coarse beds" = non-shale interbeds; "OB" = overburden.

top (m)	bottom (m)	unit #	% coarse beds	Unit Description	Strati-graphy
0.00	1.60	OB	n/a	brown, clayey soil down to 0.38 m; below this, tan/buff clay-silty clay gradually becoming grey with depth.	Blue Mountain Fm
1.60	3.35	1	<2	grey shale, non-calcareous, with harder shale (siltstone?) intervals, very brittle and fissile; local < 1 cm thick, bioclastic limestone beds.	
3.35	7.25	2	<5	grey shale, with thin (1 - 2 cm) beds of non-calcareous, hard shale (siltstone?) and limestone.	
7.25	12.27	3	20	grey shale, with non- to slightly calcareous hard shale beds (up to 7 cm thick; averaging 3 cm) and bioclastic or horizontally laminated limestone beds (up to 8 cm thick; averaging 3 cm).	
12.27	14.95	4	<2	grey shale, with a few thin (1 - 2 cm), very fossiliferous, bioclastic beds; shale is fossiliferous; local graptolites.	
14.95	17.09	5	30	grey shale with thin (1 - 2 cm thick), beds of non-calcareous hard shale or siltstone, and a few minor bioclastic limestone beds; local graptolites.	
17.09	18.31	6	30	grey shale with higher proportion of limestone and hard shale; limestone beds are mostly horizontally laminated with some bioclastic intervals and are up to 10 cm thick (averaging 4 cm).	
18.31	22.46	7	<5	grey shale with minor </= 2 cm thick, bioclastic limestone beds, spaced ~ 1 m apart.	
22.46	24.97	8	10	grey shale with hard shale intervals, thin lenses of bioclastic limestone and horizontally laminated limestone beds.	
24.97	27.73	9	15	grey shale with hard shale intervals and thin limestone beds; limestone is predominantly fine- to medium-grained and horizontally laminated, up to 8 cm thick (averaging 3 cm).	
27.73	30.4	10	0	grey shale with few non-calcareous, harder grey shale intervals </= 2 cm thick throughout unit.	

top (m)	bottom (m)	unit #	% coarse beds	Unit Description	Strati-graphy
30.4	32.63	11	15	grey shale with some limestone beds and hard shale intervals; limestone is fine- to medium-grained, horizontally laminated in up to 3 cm thick beds (averaging 2 cm); shale appears to become darker from this unit downwards to the end of the hole.	Blue Mountain Fm
32.63	34.28	12	0	dark grey shale; shale is typically very fissile but also contains some massive and hard intervals (siltstone?).	
34.28	36.75	13	10	dark grey shale with intervals of thinly interbedded shale and argillaceous limestone and individual limestone beds up to 2 cm thick with horizontal lamination, locally capped by ripple laminae.	
36.75	41.86	14	15	similar to unit 13 but with a higher proportion of hard calcareous intervals; limestone beds up to 3 cm thick; local graptolites.	
41.86	44.12	15	0	grey shale with fossiliferous shale intervals .	

Table 6-5: Lithologic log for drill hole OGS-01-04 (station 01DKA-033). "coarse beds" = non-red shale components in Queenston Fm and non-shale interbeds in Georgian Bay Fm; "OB" = overburden.

top (m)	bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
0.00	7.20	1	5	weathered red and green clayey shale (upper 0.35 m); rest of unit is interbedded red and green shale with thin (</= 6cm) light green to light red calcisiltite beds with local low angle lamination; shale becomes more fissile with depth.	Queenston Formation
7.20	11.90	2	10	thinly interbedded and interlaminated red shale, green shale and light green and red siltstone; siltstones typically interlaminated with correspondingly coloured shale; local intraclastic lags and large mudcracks with warped green shale, and locally irregular and warped bedding.	
11.90	13.82	3	40	interbedded grey calcisiltite, green shale and red shale; calcisiltite contains low angle laminations and ripple cross-lamination and are up to 9 cm thick (averaging ~3 cm) thick and contains local burrows and/or mudcracks; transitional into Georgian Bay Formation.	
13.82	15.47	4	25	thinly interbedded grey-green shale and light green calcisiltite with very minor light blue-grey bioclastic limestone beds; calcisiltite is typically </=1 cm thick (one bed is 15 cm) with ripple lamination and burrows.	Georgian Bay Formation
15.47	17.99	5	40	interbedded green-grey shale, light blue-grey, medium- to coarse-grained, bioclastic limestone and minor light grey to light brownish grey calcisiltite beds; calcisiltite beds are typically < 3 cm thick, with low angle lamination; limestone beds are mainly bioclastic and about 4 cm thick (one bed is 10 cm) and locally contains pyrite blebs and pyrite-replaced fossils, and barite(?).	
17.99	23.66	6	50	interbedded light grey calcisiltite, grey shale and light grey fossiliferous limestone; calcisiltite beds usually < 4 cm thick, contain low angle cross lamination, and grade upwards into shaly calcisiltite and eventually into shale; some have fossiliferous bases; limestone locally contains pink mineral (barite?).	
23.66	30.38	7	20	mostly shale, interbedded with calcisiltite and fossiliferous limestone; limestone beds up to 5 cm thick with local pink mineral (barite?) and pyrite blebs; calcisiltite beds more abundant at top and bottom of unit, are typically <4 cm thick (some up to 7 cm), and locally contain burrows.	

top (m)	bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
30.38	31.94	8	65	mostly limestone, interbedded with shale; limestone beds up to 20 cm thick range from fossiliferous grainstone or packstone to laminated calcisiltite and are sometimes graded; shale intervals are up to 15 cm thick, typically </= 5 cm.	Georgian Bay Formation
31.94	35.60	9	30	shale-dominated, with interbedded shale and limestone; limestone beds up to 13 cm thick (averaging < 5 cm); limestone beds same as in overlying unit.	
35.60	37.03	10	65	limestone and shale; limestone beds up to 20 cm thick (averaging 12 cm); limestone is typically graded, from fossiliferous grainstone/packstone base through low angle laminated calcisiltite to dark green shale at top; locally contains pyrite blebs.	
37.03	40.07	11	15	mostly shale with some limestone beds up to 6 cm thick; limestone is bioclastic, also with light grey laminated calcisiltite, usually with rippled top and ranging from < 1 cm to > 6 cm thick.	
40.07	42.18	12	50	interbedded shale and limestone with thick limestone beds (especially at top and bottom of unit); limestone beds up to 21 cm thick (averaging 10 cm), mostly calcisiltite with cross lamination and bioclastic bases; some beds are bioclastic limestone with pyrite and barite(?).	
42.18	44.44	13	15	mostly shale with thin, sparse limestone beds; limestone beds are mostly calcisiltite and typically </= 3 cm thick; few thin bioclastic beds.	
44.44	45.48	14	55	limestone and shale; shale intervals < 10 cm; limestone beds </=17 cm and are predominantly calcisiltite.	
45.48	47.94	15	10	grey-green shale with sparse, thin limestone beds; limestone beds are up to 4 cm thick, and most are < 1 cm; limestone varies from calcisiltite to packstone to bioclastic grainstone.	
47.94	48.76	16	50	limestone and shale; limestone beds up to 13 cm thick (averaging 7 cm).	
48.76	51.13	17	15	mostly shale with few significant limestone beds up to 6 cm thick; limestone is mostly calcisiltite, with local bioclastic lags.	

top (m)	bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
51.13	52.12	18	75	limestone and shale; mostly calcisiltite, locally non-horizontal (beds at an angle); some limestone is bioclastic packstone; beds up to 17 cm thick, averaging 8 cm thick; local thin gypsum seams.	Georgian Bay Formation
52.12	53.37	19	15	mostly shale with calcisiltite; calcisiltite beds are < 1 cm thick and are rippled and lensy; basal bed is 5 cm thick graded bioclastic limestone bed, overlain by 4 cm calcisiltite, grading up into shale.	
53.37	56.61	20	40	limestone and shale; limestone beds up to 17 cm thick (averaging 6 cm thick); limestone is mostly calcisiltite but also includes some bioclastic beds.	
56.61	59.11	21	10	mostly shale with few limestone beds (rippled calcisiltite) </= 3 cm thick.	
59.11	60.13	22	50	limestone and shale; limestone beds up to 10 cm thick (averaging 4 cm).	
60.13	61.08	23	15	shale with limestone (calcisiltite) beds typically < 4 cm thick.	

Table 6-6: Lithologic log for drill hole OGS-01-05 (station 01DKA-034). "coarse beds" = non-red shale components in Queenston Fm and non-shale interbeds in Georgian Bay Fm; "OB" = overburden.

top (m)	bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
0.00	2.59	OB	n/a	dark brown soil down to 0.20 m, grading down into yellow-stained, green-grey till ot 0.4 m, followed by brownish grey silty, clayey till; shale clasts and reddish colour increase with depth.	Quat-ernary
2.59	4.22	1	10	mostly red shale, with green shale and minor red-brown and light green siltstone beds; some siltstone beds are horizontally laminated.	Queenston Formation
4.22	4.68	2	80	light and dark red, and green mottled calcisiltite; light coloured beds are siltstone with ripples and low angle laminations.	
4.68	7.59	3	40	thinly interbedded grey-green shale and light grey-green calcisiltite; limestone beds mostly calcisiltite with some ripples, and are up to 3 cm thick; sparse fossils.	Georgian Bay Formation
7.59	8.50	4	80	similar as overlying unit, except thicker (up to 11 cm) and more abundant limestone beds; limestone beds are calcisiltite or fine- to medium-grained bioclastic limestone; thin gypsum seam at 7.98 m.	
8.50	9.07	5	20	shale with calcisiltite beds </= 3 cm thick, with ripple lamination.	
9.07	9.80	6	70	similar as unit 4, with same limestone types; limestone beds are up to 11 cm thick.	
9.80	14.34	7	40	interbedded limestone and shale; limestone is typically light grey, fine-grained calcisiltite, with ripples and cross-stratification, or fine- to coarse-grained, light grey, bioclastic limestone; some limestones are bryozoan-rich wackestones or dark greenish grey fine-grained massive limestone with gradational contacts with shale; limestone beds are up to 11 cm thick (averaging 7 cm).	
14.34	15.63	8	10	shale-dominated, with few limestone beds up to 5 cm thick (averaging 2 cm); limestone types as above in unit 7.	
15.63	16.82	9	30	shale with limestone beds; limestone beds are up to 12 cm thick and are calcisiltite or bioclastic limestone.	

top (m)	bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
16.82	19.35	10	10	mostly shale with limestone interbeds; limestone is similar types as above and are </= 4 cm thick.	Georgian Bay Formation
19.35	21.88	11	40	shale and limestone; limestone is similar to types above, as well as some dark grey to black, very fine- to fine-grained limestone; beds are up to 13 cm thick (averaging 7 cm); some shale is dark grey and hard and grades into dark limestone.	
21.88	23.49	12	55	limestone with shale; limestone is mostly fine-grained calcisiltite, sometimes with ripple cross-stratification; also some fine- to coarse-grained bioclastic limestone with bryozoans, shells and pink/orange minerals (barite?); limestone beds are up to 18 cm thick (averaging 8 cm).	
23.49	23.96	13	25	mostly shale with some thin limestone beds; one 6 cm thick bed has a bioclastic lag; beds are mostly </=3 cm.	
23.96	24.68	14	40	limestone with shale; most beds </= 5 cm thick.	
24.68	25.78	15	15	shale with thin limestone beds up to 2 cm thick; one calcisiltite bed is 5 cm thick.	
25.78	28.16	16	50	limestone with shale; most beds </= 5 cm thick; limestone is mostly calcisiltite with dark grey tops; some beds are bioclastic packstone and or wackestone.	
28.16	32.10	17	15	shale and limestone; limestone beds up to 7 cm (most are </= 3 cm); bioclastic limestone bed at 30.82 to 30.88 m.	
32.10	32.56	18	90	limestone with minor shale intervals; limestone beds up to 13 cm thick; mostly calcisiltite with bioclastic lags.	
32.56	35.04	19	10	shale with local hard shale and minor limestone beds; limestone is mostly calcisiltite.	
35.04	35.88	20	55	limestone and shale; limestone beds are up to 16 cm thick, and are mostly ripple laminated calcisiltite, with bioclastic intervals.	
35.88	38.48	21	5	mostly shale; limestone beds </= 5 cm and are bioclastic or calcisiltite.	
38.48	39.11	22	40	limestone with shale; limestone beds up to 20 cm thick (averaging 10 cm); limestone is moslty calcisiltite with minor lag.	

top (m)	bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
39.11	41.13	23	20	shale with limestone beds up to 12 cm thick (averaging 7 cm); beds are mostly calcisiltite, some minor bioclastic beds.	Georgian Bay Formation
41.13	41.87	24	70	limestone with shale; limestone beds up to 20 cm thick (averaging 7 cm); limestone is mostly calcisiltite with minor bioclastic lags; some beds are graded and bioclastic containing pinkish nodules (barite?).	
41.87	45.97	25	15	mostly grey shale with limestone beds averaging 4 cm thick; also some thin (</= 2 cm thick) calcisiltite beds; limestone is mostly calcisiltite and contains pyrite; some limestones are bioclastic.	
45.97	46.28	26	90	limestone with minor shale; basal bed is 25 cm thick and grades from bioclastic to laminated calcisiltite at top and contains pyrite; also, most dark grey, very fine-grained limestones appear to be hard, non-calcareous shale.	
46.28	48.74	27	10	shale with thin limestone beds < 3 cm thick; limestones are predominantly calcisiltite (one bed is bioclastic); some dark grey, hard shale.	
48.74	49.69	28	30	limestone and shale; limestone beds up to 13 cm thick (averaging 7 cm); limestone is mainly calcisiltite, with some bioclastic intervals.	
49.69	51.42	29	10	shale with limestone beds up to 7 cm thick; limestone is laminated calcisiltite, bioclastic packstone or ripple-laminated calcisiltite with fossil lag.	
51.42	52.32	30	60	limestone with shale; limestone beds up to 8 cm thick (averaging 5 cm); limestone is bioclastic with pyrite, or laminated calcisiltite.	
52.32	56.14	31	10	shale with limestone; limestone beds are mainly cross-laminated calcisiltite up to 5 cm thick, but most are < 2 cm thick.	
56.14	58.47	32	55	grey shale with abundant limestone interbeds; limestone beds are mostly horizontally laminated with minor cross-stratifications and are up to 15 cm thick (averaging 6 cm) and contain bioclastic lags; some bioturbation and load casts.	
58.47	61.27	33	15	mostly grey shale and dark calcisiltite, with minor limestone at base of unit; limestone is typically horizontally laminated; one 5 cm thick bioclastic bed.	

Table 6-7: Lithologic log for drill hole OGS-01-06 (station 01DKA-035). "coarse beds" = non-red shale components in Queenston Fm and non-shale interbeds in Carlsbad Fm; "OB" = overburden; red shale is non-calcareous unless stated otherwise.

Top (m)	Bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
0.00	1.50	OB	n/a	top 15 cm is soil with organic material (grass, roots, etc.); rest is clayey weathered red-brown shale; shale is not very fissile; may be fill from quarry material; sparse granitic pebbles and green mottled shale clasts.	Quat-ernary
1.50	2.20	1	0	red shale; very fissile from 1.50 to 1.75 m, massive and irregular rubbly recovery for rest of unit; slightly calcareous.	Queenston Formation
2.20	3.75	2	0	massive red shale, slightly calcareous.	
3.75	4.24	3	50	red massive shale with two hard green beds up to 7 cm thick (averaging 4 cm); beds apprear to consist of grey-green calcisiltite centres with green shale borders.	
4.24	10.15	4	5	massive red shale; 6 cm light red calcisiltite bed at 7.60 to 7.66 m; minor intervals of thinly interbedded shale and siltstone; irregular mold after gypsum nodule(?) at 8.10 m.	
10.15	13.95	5	5	red massive shale with regular intervals of hard, green beds up to 8 cm thick; green beds are typically interbedded, horizontally laminated green and light red calcisiltite or green calcisiltite and green shale, with either sharp or gradational contacts, or mottled; mudcracks.	
13.95	15.04	6	65	red shale with abundant green calcisiltite, green shale, and light red calcisiltite interbeds; limestone is mostly fine- to medium-grained, grey-green, calcisiltite to calcarenite, and locally, is horizontally laminated; also intervals of thinly interbedded red shale, and green and light red calcisiltite; limestone beds are up to 18 cm thick; local mudcracks and rip up clasts.	
15.04	16.66	7	5	mostly red shale, with thin (</= 5 cm) green-grey calcisiltite interbeds.	
16.66	19.60	8	50	interbedded red shale, grey-green calcisiltite, green shale and light red calcisiltite; shale intervals up to 20 cm thick and are less massive, containing intraclasts and minor gypsum nodules; red and green calcisiltites contain dessication cracks; local warped green beds.	
19.60	21.51	9	35	similar as unit 8, except shale intervals average 15 cm thick; frequent intervals of interlaminated red shale, red and green calcisiltite; calcisiltite beds up 7 cm thick (average <2 cm) and contain mudcracks and irregular bedding.	

Top (m)	Bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
21.51	22.95	10	40	thinly interlaminated light red calcisiltite and red shale, with minor grey-green calcisiltite beds; local mudcracks and irregular bedding; calcisiltite beds average 2 cm thick and are evenly distributed throughout unit; transitional to underlying Carlsbad Formation (still predominantly reddish colour).	Queenston Formation
22.95	27.79	11	60	mainly alternating bioclastic and laminated limestones, with minor red-brown shale; beds are up to 50 cm thick (averaging 10 cm); bioclasts are moslty trilobite fragments, cephalopods, crinoids and bryozoans; horizontally laminated limestones locally contain stylolites; contact with the overlying Queenston Formation placed at top of first decimetric-scale bioclastic limestone bed; still somewhat transitional and predominantly reddish-grey.	Carlsbad Formation
27.79	32.93	12	80	mainly limestone, with some argillaceous limestone and minor shale; limestone beds are up to 50 cm thick (averaging 15 cm); limestone is mostly fine-grained and horizontally laminated, with stylolites; unit also contains bioclastic limestones (similar to those in overlying unit) and argillaceous, bioturbated limestones; bedding is locally irregular and warped; some reddish tones at top of unit, but all red dissappears by ~28 m depth.	
32.93	34.71	13	45	interbedded limestone and shale, with some intervals of thinly interlaminated shale and limestone with warped beds; limestone is fine-grained and horizontally laminated with beds up to 20 cm thick (averaging 5 cm); no mudcracks, but some bioturbation.	
34.71	36.19	14	95	limestone, with minor shale; top of unit is 50 cm limestone bed followed by smaller interbeds of limestone and dark grey shale; limestone is typically fine- to medium-grained, horizontally laminated with little to no fossil content; individual beds average 15 cm thick, however thicker intervals contain successions of smaller limestone beds; some irregular bedding especially within intervals of thinly interlaminated shale and limestone; local intracalsts and intense bioturbation.	
36.19	40.74	15	45	interbedded dark grey shale and limestone, with intervals of thinly interlaminated shale and limestone with limestone-filled burrows and rip-up clasts; shale is very bioturbated; limestone is horizontally laminated and beds are up to 8 cm thick (averaging 3 to 4 cm); local fossil fragments in shale.	

Top (m)	Bottom (m)	Unit #	% coarse beds	Unit Description	Strati-graphy
40.74	45.20	16	25	similar to unit 15, except with little to no bioturbation in shale and a lower proportion of overall limestone content; limestone beds up to 20 cm thick (averaging 7 cm) and are horizontally laminated with thin bioclastic intervals; sharper contacts between shale and limestone; presence of pyrite around 42.90 m, commonly in limestone and locally in shale; 1 mm thick calcite-filled subvertical fracture from 42.93 to 43.22 m.	Carlsbad Formation
45.20	47.42	17	65	similar to unit 16, but more limestone; limestone beds up to 20 cm thick (averaging 5 cm) and are mostly fine- to medium-grained and horizontally laminated, with some slightly bioclastic beds; local irregular bedding due to soft sediment deformation and rip-ups; pyrite.	
47.42	54.88	18	20	mostly grey shale, with several limestone beds up to 20 cm thick (averaging 7 cm thick); same limestone types as overlying units and in same proportions; pyrite and calcite-filled subvertical fractures.	
54.88	56.08	19	90	limestone-dominated with minor grey shale intervals; limestone beds are up to 20 cm thick (averaging 15 cm); limestone is same types and proportions as above; no more pyrite, but increasing number of thin calcite-filled subvertical fractures .	
56.08	57.67	20	20	shale-dominated, with some limestone beds and some thinly interbedded (< 1cm thick interbeds) shale and limestone; limestone beds are mainly horizontally laminated and up to 10 cm thick (averaging 4 cm).	
57.67	60.96	21	35	shale with limestone beds; shale interval at 59.20 to 59.30 m is slightly bioclastic; limestone is same type as above and beds up to 15 cm thick (averaging 5 cm).	

Table 6-8a: Locations and descriptions of 2001 drill core bed samples. "Fm" = formation; formation codes: G = Georgian Bay, Q = Queenston, C = Carlsbad. Samples 01DKA030e to 01DKA030h are from drill hole OGS-01-01. Samples 01DKA031g to 01DKA031j are from drill hole OGS-01-02. Samples 01DKA034e to 01DKA034h are from drill hole OGS-01-05. Samples 01DKA035a to 01DKA035ap are from drill hole OGS-01-06.

Sample #	Depth (m)		Litho-logic unit #	Fm	sample description
	from	to			
01DKA030e	4.55	4.65	2	G	shale
01DKA030f	6.40	6.48	3	G	limestone
01DKA030g	29.66	29.79	10	G	shale
01DKA030h	29.48	29.56	10	G	limestone
01DKA031g	9.70	9.80	2	G	shale
01DKA031h	10.07	10.15	2	G	limestone
01DKA031i	35.60	35.70	8	G	shale
01DKA031j	35.15	35.20	8	G	laminated, fine-grained, grey limestone, with minor shale (<10%) at top and bottom
01DKA034e	10.14	10.19	7	G	shale
01DKA034f	10.82	10.88	7	G	laminated, fine-grained, grey limestone
01DKA034g	58.09	58.19	32	G	shale
01DKA034h	58.30	58.40	32	G	laminated, fine-grained, grey limestone
01DKA035a	1.55	1.65	1	Q	red shale
01DKA035b	3.10	3.20	2	Q	massive red shale
01DKA035c	4.14	4.24	3	Q	60% green/light green shale and siltstone and 40% red shale
01DKA035d	4.65	4.75	4	Q	massive red shale
01DKA035e	6.10	6.20	4	Q	massive red shale
01DKA035f	7.67	7.77	4	Q	massive red shale
01DKA035g	9.20	9.30	4	Q	massive red shale
01DKA035h	10.64	10.74	5	Q	massive red shale
01DKA035i	12.09	12.15	5	Q	massive red shale
01DKA035j	13.74	13.84	5	Q	massive red shale
01DKA035k	14.45	14.55	6	Q	interbedded red shale and light red siltstone and shale balls and rip-ups
01DKA035l	15.29	15.39	7	Q	80% red shale with two 1 cm beds of light red siltstone with mudcracks and laminations
01DKA035m	16.84	16.94	8	Q	laminated light green and red (45%) and 1 cm light green siltstone and 45% red clasts and shale
01DKA035n	18.39	18.49	9	Q	30% green shale and light green siltstone, 70% red shale

Sample #	Depth (m)		Litho-logic unit #	Fm	sample description
	from	to			
01DKA035o	19.89	19.99	9	Q	70% red shale and light red siltstone (20%) and green shale (10%)
01DKA035p	21.41	21.51	9	Q	90% red shale and 10 % light red siltstone
01DKA035q	22.82	22.94	10	Q	80% light red siltstone, 20% red shale and 2 <1 mm gyp seams at 22.91 m and 22.92 m
01DKA035r	24.39	24.51	11	C	similar to 01DKA035q, with 10% dark green shale at base and 10% red shale (transitional)
01DKA035s	25.93	26.03	11	C	bioclastic red limestone (transistional)
01DKA035t	27.51	27.61	11	C	thin interbedded green and red siltstone (60%) and shale (40%) (transitional)
01DKA035u	29.06	29.16	12	C	green argillaceous limestone and bioclastic limestone (20%) and green shale (10%)
01DKA035v	30.56	30.68	12	C	grey limestone, fine- to medium-grained
01DKA035w	32.08	32.18	12	C	fossiliferous argillaceous limestone, with 10% grey shale
01DKA035x	33.58	33.68	13	C	fine-grained grey limestone (50%), dark green-grey massive shale (50%)
01DKA035y	35.15	35.25	14	C	grey limestone with stylolites and 10% dark grey-green shale at base
01DKA035z	36.68	36.78	15	C	60% limestone, 40% shale
01DKA035aa	38.23	38.33	15	C	40% grey limestone, 60% dark grey-green fissile shale
01DKA035ab	39.70	39.80	15	C	70% limestone, 30% dark green shale
01DKA035ac	41.27	41.37	16	C	90% shale 10% limestone
01DKA035ad	42.80	42.90	16	C	20% limestone, 80% shale (10% dark green to black)
01DKA035ae	44.31	44.42	16	C	80% very fine-grained, grey-green limestone (shale?), 20% fine-grained limestone with pyrite blebs
01DKA035af	45.80	45.90	17	C	30% fine-grained limestone, 70% grey-green shale/limestone(?)
01DKA035ag	47.31	47.42	17	C	95% limestone with pyrite and some fossils, 5% shale
01DKA035ah	48.69	48.79	18	C	grey-green shale (very fine-grained limestone?)
01DKA035ai	50.39	50.49	18	C	60% limestone, 40% dark grey shale
01DKA035aj	51.94	52.04	18	C	bioclastic limestone with pyrite
01DKA035ak	53.42	53.52	18	C	shale and very fine-grained limestone
01DKA035al	54.99	55.09	19	C	mostly shale, <10% limestone
01DKA035am	56.46	56.56	20	C	dark grey shale/limestone
01DKA035an	57.81	57.91	21	C	fine-grained limestone with horizontal laminations
01DKA035ao	59.32	59.43	21	C	40% fine-grained limestone with low angle laminations, 60% dark grey shale; with subvertical calcite-filled fracture
01DKA035ap	60.86	60.96	21	C	dark grey-green shale and 40% fine-grained limestone

Table 6-8b: Major and minor element data for 2001 drill core bed samples (see Table 6-8a for sample locations and descriptions; double lines separate samples from different stations; analytical detection limits and units listed at the bottom of the table).

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S	Fe2O3/CO2
01DKA030e	57.09	15.10	0.10	3.23	4.37	0.87	4.00	0.15	0.78	6.46	7.76	99.91	4.05	0.47	1.60
01DKA030f	56.66	8.26	0.21	2.24	12.51	1.22	1.69	0.11	0.46	3.49	12.77	99.60	10.50	0.05	0.33
01DKA030g	56.90	15.53	0.11	3.29	3.26	0.94	4.13	0.18	0.84	6.52	8.78	100.48	2.98	0.07	2.19
01DKA030h	61.87	7.88	0.20	2.80	8.36	1.29	1.70	0.12	0.53	4.13	10.03	98.90	8.18	0.41	0.50
01DKA031g	56.50	17.98	0.08	3.74	1.55	0.47	5.19	0.21	0.92	7.24	6.67	100.55	1.66	0.12	4.36
01DKA031h	51.68	9.43	0.23	2.00	14.67	1.10	2.05	0.13	0.50	3.84	14.34	99.95	11.80	0.02	0.33
01DKA031i	54.36	17.13	0.10	3.62	3.27	0.69	4.59	0.24	0.86	7.45	7.84	100.14	3.40	0.34	2.19
01DKA031j	49.33	9.39	0.22	2.09	14.99	1.02	2.24	0.16	0.54	4.64	14.76	99.38	13.50	0.15	0.34
01DKA034e	47.01	14.81	0.10	5.82	7.47	0.19	4.64	0.14	0.69	5.88	12.95	99.69	9.30	0.53	0.63
01DKA034f	44.29	6.27	0.11	4.76	18.23	0.12	2.95	0.15	0.36	2.66	19.76	99.67	17.40	0.17	0.15
01DKA034g	56.01	16.84	0.09	3.97	2.27	0.23	5.89	0.20	0.79	6.70	7.36	100.36	2.76	0.43	2.43
01DKA034h	48.14	12.80	0.13	1.70	12.84	0.72	5.28	0.20	0.39	2.56	14.16	98.92	9.98	0.21	0.26
01DKA035a	57.71	15.56	0.11	2.81	4.30	1.04	3.76	0.14	0.78	6.92	7.61	100.74	3.29	0.01	2.10
01DKA035b	57.79	15.40	0.10	2.90	4.35	1.07	3.77	0.13	0.77	6.47	7.71	100.48	3.37	0.01	1.92
01DKA035c	60.05	13.90	0.13	2.60	5.60	1.30	3.16	0.13	0.72	4.27	8.05	99.92	4.41	0.02	0.97
01DKA035d	57.92	15.66	0.10	2.99	3.89	1.08	3.84	0.13	0.79	6.97	7.25	100.61	3.04	0.02	2.29
01DKA035e	58.42	15.95	0.08	3.03	3.35	1.08	3.92	0.14	0.81	6.94	6.97	100.68	2.63	0.01	2.64
01DKA035f	59.12	15.62	0.09	2.96	3.31	1.14	3.78	0.13	0.79	6.93	6.80	100.67	2.52	0.02	2.75
01DKA035g	57.66	14.98	0.12	2.86	5.06	1.15	3.55	0.13	0.75	6.47	7.93	100.66	4.00	0.02	1.62
01DKA035h	55.06	15.94	0.10	3.15	5.14	0.94	3.98	0.13	0.78	6.79	8.47	100.47	4.08	0.02	1.66
01DKA035i	58.19	16.07	0.08	3.10	3.18	1.13	3.98	0.13	0.81	7.17	6.97	100.81	2.47	0.01	2.90
01DKA035j	57.87	15.88	0.09	3.09	3.47	1.06	3.96	0.14	0.79	7.21	7.01	100.56	2.73	0.01	2.64
01DKA035k	60.36	13.46	0.14	2.54	5.54	1.45	2.97	0.14	0.75	5.35	7.71	100.42	4.37	0.01	1.22
01DKA035l	58.07	14.76	0.12	2.87	4.74	1.17	3.57	0.14	0.76	6.29	7.90	100.39	3.79	0.01	1.66
01DKA035m	58.16	14.29	0.15	2.85	5.65	1.22	3.34	0.14	0.73	5.27	8.37	100.17	4.66	0.01	1.13
01DKA035n	57.82	14.99	0.14	2.92	4.78	1.17	3.63	0.13	0.74	6.25	7.82	100.38	3.88	0.01	1.61
01DKA035o	59.74	15.44	0.09	3.04	3.42	1.21	3.73	0.14	0.78	6.18	6.83	100.60	2.76	0.01	2.24

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S	Fe2O3/CO2
01DKA035p	59.33	16.26	0.08	3.17	2.21	1.13	4.07	0.14	0.82	7.29	6.20	100.69	1.78	0.01	4.10
01DKA035q	60.34	11.69	0.18	3.05	5.70	1.39	2.16	0.14	0.65	7.41	8.06	100.78	5.24	0.05	1.41
01DKA035r	59.72	13.82	0.13	2.95	4.96	1.31	3.01	0.15	0.76	5.40	7.85	100.07	4.27	0.01	1.26
01DKA035s	18.94	3.53	0.57	3.23	37.82	0.40	0.68	0.08	0.17	2.59	32.79	100.80	31.60	0.06	0.08
01DKA035t	59.80	16.34	0.07	3.44	1.89	1.08	3.90	0.14	0.83	7.06	6.20	100.77	1.75	0.01	4.03
01DKA035u	55.02	11.10	0.24	3.46	9.45	1.19	2.06	0.12	0.58	4.57	11.03	98.80	9.50	0.46	0.48
01DKA035v	6.00	1.54	0.62	2.88	47.25	0.11	0.30	0.06	0.06	1.45	40.33	100.60	39.40	0.03	0.04
01DKA035w	27.93	6.10	0.58	5.88	26.20	0.66	1.24	0.08	0.30	3.89	27.44	100.31	26.00	0.15	0.15
01DKA035x	57.22	13.57	0.18	3.96	5.61	1.21	2.82	0.14	0.69	5.64	9.47	100.51	6.33	0.03	0.89
01DKA035y	17.59	3.88	0.44	1.65	39.99	0.42	0.75	0.09	0.17	2.24	33.19	100.40	32.00	0.04	0.07
01DKA035z	59.53	14.26	0.15	3.65	4.15	1.28	3.06	0.14	0.75	5.63	8.01	100.61	4.88	0.10	1.15
01DKA035aa	57.98	15.33	0.12	3.78	3.51	1.20	3.41	0.13	0.77	6.03	8.10	100.36	4.14	0.09	1.46
01DKA035ab	47.57	8.61	0.23	2.73	16.40	1.19	1.67	0.12	0.48	4.27	16.24	99.53	14.40	0.06	0.30
01DKA035ac	57.32	15.89	0.11	3.74	3.59	1.15	3.64	0.13	0.82	6.22	7.93	100.55	3.87	0.10	1.61
01DKA035ad	55.12	14.69	0.11	3.25	6.33	1.21	3.22	0.13	0.74	5.75	9.08	99.64	6.16	0.31	0.93
01DKA035ae	58.61	16.16	0.08	3.35	2.57	1.24	3.83	0.15	0.85	6.43	6.15	99.43	2.86	0.80	2.25
01DKA035af	53.94	15.31	0.13	3.81	5.73	1.07	3.55	0.15	0.76	5.89	9.69	100.03	6.14	0.18	0.96
01DKA035ag	34.21	6.14	0.27	2.07	24.66	1.02	1.16	0.13	0.33	7.13	16.65	93.77	20.20	3.27	0.35
01DKA035ah	56.92	16.19	0.09	3.57	3.56	1.13	3.86	0.15	0.81	6.10	7.58	99.97	3.83	0.22	1.59
01DKA035ai	51.15	12.81	0.15	2.60	11.29	1.34	2.50	0.14	0.66	4.76	12.58	99.96	9.86	0.09	0.48
01DKA035aj	7.30	1.80	0.30	1.31	43.94	0.23	0.37	0.05	0.07	6.80	28.97	91.13	35.60	4.12	0.19
01DKA035ak	53.02	13.51	0.15	2.74	9.25	1.35	2.75	0.15	0.72	5.12	11.14	99.90	8.23	0.08	0.62
01DKA035al	59.83	16.34	0.08	3.19	2.42	1.27	3.86	0.15	0.84	5.76	6.71	100.44	2.64	0.12	2.18
01DKA035am	57.61	16.68	0.09	3.35	2.91	1.14	3.91	0.15	0.83	6.47	7.16	100.30	3.06	0.18	2.11
01DKA035an	59.20	11.50	0.18	2.38	8.38	1.53	2.09	0.14	0.66	4.51	9.75	100.33	7.44	0.07	0.61
01DKA035ao	55.84	15.03	0.12	3.11	5.03	1.24	3.35	0.17	0.76	6.46	8.20	99.31	4.97	0.38	1.30
01DKA035ap	58.61	16.13	0.08	3.20	3.01	1.23	3.72	0.17	0.83	6.51	6.75	100.24	3.18	0.24	2.05
detection limits:	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	n/a	0.03	0.01	n/a
units:	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	n/a

Table 6-9: Geochemical data and sample information for 2001 drill core composite samples. (double lines separate samples from different stations; analytical detection limits and units listed at the end of the table).

Sample #	Depth (m)		Litho-logic unit #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S	Fe2O3/ CO2
	From	To																
01DKA130a	1.50	3.17	1	52.48	13.84	0.15	3.02	8.27	0.75	3.52	0.15	0.70	6.21	10.40	99.50	6.81	0.42	0.91
01DKA130b	3.17	6.40	2	54.23	15.83	0.12	3.53	4.82	0.67	4.29	0.19	0.82	6.78	8.73	100.01	4.47	0.03	1.52
01DKA130c	6.40	8.07	3	56.15	15.72	0.11	3.41	4.42	0.74	4.21	0.16	0.80	6.55	8.24	100.50	4.12	0.02	1.59
01DKA130d	8.07	9.85	4	56.01	15.34	0.12	3.39	4.98	0.83	4.06	0.16	0.80	6.38	8.57	100.62	4.82	0.03	1.32
01DKA130e	9.85	14.51	5	55.12	14.96	0.12	3.24	5.75	0.81	3.93	0.16	0.78	6.25	9.14	100.26	5.40	0.02	1.16
01DKA130f	14.51	17.85	6	54.43	15.79	0.11	3.42	4.46	0.78	4.22	0.18	0.82	6.61	9.48	100.28	4.20	0.03	1.57
01DKA130g	17.85	23.84	7	56.99	14.63	0.12	3.27	4.72	0.93	3.81	0.18	0.79	6.28	8.57	100.29	4.49	0.03	1.40
01DKA130h	23.84	26.08	8	55.92	16.49	0.10	3.45	3.04	0.82	4.48	0.19	0.88	7.02	7.70	100.10	2.76	0.05	2.54
01DKA130i	26.08	28.22	9	56.10	15.66	0.10	3.31	3.36	0.84	4.25	0.17	0.84	6.69	8.73	100.04	3.12	0.05	2.14
01DKA130j	28.22	32.00	10	55.30	14.46	0.14	3.26	5.58	0.92	3.76	0.17	0.78	6.26	9.45	100.07	5.11	0.05	1.23
01DKA131a	2.25	7.29	1	54.25	14.86	0.13	3.10	6.57	0.66	3.98	0.19	0.78	6.25	9.33	100.09	5.94	0.12	1.05
01DKA131b	7.29	11.40	2	54.18	13.46	0.15	3.01	7.99	0.76	3.52	0.18	0.73	5.74	10.13	99.86	6.72	0.18	0.85
01DKA131c	11.40	13.61	3	55.07	16.38	0.12	3.72	3.81	0.61	4.49	0.22	0.86	7.31	7.81	100.38	3.78	0.19	1.93
01DKA131d	13.61	17.16	3	54.59	16.53	0.12	3.74	3.85	0.61	4.52	0.21	0.86	7.32	7.89	100.23	3.84	0.15	1.91
01DKA131e	17.16	20.03	4	55.38	13.45	0.15	3.25	6.79	0.85	3.55	0.18	0.76	5.81	9.55	99.72	6.37	0.14	0.91
01DKA131f	20.03	22.47	4	54.84	12.16	0.19	3.50	7.37	0.97	3.16	0.17	0.69	5.57	10.42	99.05	7.46	0.30	0.75
01DKA131g	22.47	24.58	5	55.09	16.21	0.12	3.49	4.08	0.71	4.38	0.21	0.85	7.00	7.72	99.86	3.98	0.24	1.76
01DKA131h	24.58	27.44	5	55.46	15.80	0.12	3.38	4.49	0.77	4.16	0.20	0.84	6.94	7.83	100.00	4.18	0.21	1.66
01DKA131i	27.44	30.48	6	57.80	15.04	0.11	3.18	4.07	0.93	3.99	0.19	0.83	6.40	7.35	99.89	3.84	0.26	1.67
01DKA131j	30.48	32.59	6	58.15	14.26	0.11	3.01	4.99	1.05	3.61	0.18	0.81	6.04	7.59	99.81	4.58	0.35	1.32
01DKA131k	32.59	35.14	7	57.46	15.97	0.09	3.26	3.13	0.90	4.27	0.19	0.86	6.80	6.69	99.62	3.31	0.38	2.05
01DKA131l	35.14	37.72	8	55.85	16.50	0.10	3.44	3.35	0.78	4.37	0.22	0.88	7.33	7.07	99.91	3.28	0.41	2.23

Sample #	Depth (m)		Litho-logic unit #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S	Fe2O3/ CO2
	From	To																
01DKA132a	1.60	3.35	1	58.92	16.30	0.08	3.28	2.25	0.71	4.58	0.16	0.87	6.47	6.27	99.88	2.80	0.50	2.31
01DKA132b	3.35	7.25	2	57.82	16.42	0.09	3.29	2.82	0.74	4.56	0.17	0.88	6.62	6.57	99.97	3.19	0.53	2.08
01DKA132c	7.25	9.76	3	57.76	16.23	0.09	3.25	2.82	0.76	4.59	0.17	0.88	6.62	6.49	99.65	3.11	0.57	2.13
01DKA132d	9.76	12.27	3	56.10	15.24	0.09	3.10	4.66	0.81	4.15	0.13	0.81	6.41	7.49	98.98	4.73	0.82	1.36
01DKA132e	12.27	14.95	4	56.29	16.70	0.08	3.29	2.81	0.72	4.66	0.16	0.87	6.97	6.56	99.10	3.36	0.85	2.07
01DKA132f	14.95	17.09	5	57.02	16.08	0.08	3.16	3.19	0.82	4.44	0.15	0.84	6.70	6.69	99.17	3.66	0.86	1.83
01DKA132g	17.09	18.31	6	57.82	15.81	0.09	3.24	3.01	0.85	4.42	0.15	0.83	6.49	6.61	99.33	3.57	0.74	1.82
01DKA132h	18.31	22.46	7	55.37	16.61	0.10	3.48	3.29	0.72	4.62	0.17	0.84	6.83	7.39	99.44	4.00	0.67	1.71
01DKA132i	22.46	24.97	8	56.19	16.36	0.09	3.38	2.95	0.78	4.60	0.15	0.84	6.80	7.07	99.21	3.68	0.80	1.85
01DKA132j	24.97	27.73	9	56.54	16.56	0.10	3.43	2.91	0.78	4.59	0.16	0.85	6.89	7.02	99.81	3.62	0.83	1.90
01DKA132k	27.73	30.40	10	54.12	16.66	0.12	3.70	3.63	0.67	4.63	0.19	0.84	6.97	8.15	99.66	4.46	0.65	1.56
01DKA132l	30.40	32.63	11	54.69	16.45	0.10	3.42	3.32	0.70	4.59	0.16	0.84	6.79	7.63	98.69	4.08	0.76	1.66
01DKA132m	32.63	34.28	12	55.56	17.12	0.09	3.34	2.62	0.67	4.77	0.17	0.84	7.10	7.09	99.38	3.62	1.00	1.96
01DKA132n	34.28	36.75	13	56.32	17.06	0.09	3.34	2.44	0.71	4.74	0.16	0.85	7.01	6.87	99.58	3.23	0.95	2.17
01DKA132o	36.75	39.25	14	55.52	17.13	0.11	3.47	2.92	0.70	4.72	0.18	0.85	6.73	7.61	99.94	3.62	0.49	1.86
01DKA132p	39.25	41.86	14	54.70	17.19	0.10	3.46	2.95	0.63	4.78	0.17	0.84	7.07	7.50	99.39	3.77	0.84	1.88
01DKA132q	41.86	44.12	15	54.57	17.29	0.10	3.43	3.02	0.60	4.80	0.18	0.84	7.16	7.39	99.37	4.00	1.00	1.79
01DKA133a	0.35	3.71	1	43.54	12.24	0.11	3.48	14.47	0.10	3.47	0.13	0.59	5.34	16.21	99.68	12.00	0.02	0.45
01DKA133b	3.71	7.20	1	44.07	13.08	0.10	3.57	13.27	0.11	3.80	0.12	0.61	5.71	15.22	99.66	10.90	0.02	0.52
01DKA133c	7.20	9.55	2	44.41	10.44	0.11	3.47	15.16	0.26	3.64	0.13	0.56	4.83	16.19	99.19	12.60	0.02	0.38
01DKA133d	9.55	11.90	2	50.00	13.54	0.09	3.52	9.71	0.16	4.17	0.13	0.66	5.99	12.10	100.08	8.20	0.02	0.73
01DKA133e	11.90	13.82	3	43.71	9.18	0.12	3.95	16.36	0.48	3.06	0.13	0.49	4.07	17.70	99.25	14.00	0.06	0.29
01DKA133f	13.82	15.47	4	41.16	10.09	0.11	3.76	17.40	0.39	3.30	0.13	0.51	4.24	18.17	99.25	14.80	0.14	0.29
01DKA133g	15.47	17.99	5	40.38	10.16	0.11	3.76	17.55	0.45	3.22	0.13	0.49	4.65	17.63	98.54	14.40	0.49	0.32
01DKA133h	17.99	20.51	6	46.07	9.85	0.11	3.57	15.08	0.67	3.07	0.15	0.51	4.23	16.10	99.40	13.10	0.13	0.32

Sample #	Depth (m)		Litho-logic unit #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S	Fe2O3/ CO2
	From	To																
01DKA133i	20.51	23.66	6	44.61	11.02	0.13	3.72	14.89	0.55	2.96	0.17	0.54	4.54	16.19	99.31	13.00	0.25	0.35
01DKA133j	23.66	27.12	7	50.84	14.82	0.11	4.28	6.93	0.39	4.41	0.19	0.72	6.22	10.96	99.87	6.96	0.13	0.89
01DKA133k	27.12	30.38	7	51.75	13.32	0.12	3.30	9.32	0.63	3.77	0.18	0.65	5.38	11.36	99.77	8.20	0.28	0.66
01DKA133l	30.38	31.94	8	46.16	11.48	0.16	3.45	13.87	0.68	2.89	0.20	0.56	4.93	15.31	99.67	11.80	0.19	0.42
01DKA133m	31.94	35.60	9	52.33	14.11	0.11	3.22	8.35	0.72	3.89	0.18	0.72	5.68	10.78	100.09	7.04	0.13	0.81
01DKA133n	35.60	37.03	10	49.24	11.30	0.15	2.74	12.98	0.81	2.77	0.16	0.56	4.67	13.62	98.99	10.50	0.34	0.44
01DKA133o	37.03	40.07	11	49.78	13.93	0.14	3.42	9.42	0.63	3.75	0.19	0.69	5.91	12.01	99.87	8.21	0.11	0.72
01DKA133p	40.07	42.18	12	55.10	12.99	0.13	2.87	7.97	0.87	3.50	0.19	0.68	5.44	9.61	99.34	6.73	0.45	0.81
01DKA133q	42.18	44.44	13	54.04	16.67	0.10	3.66	3.98	0.58	4.86	0.21	0.84	6.99	8.14	100.08	3.75	0.10	1.86
01DKA133r	44.44	45.48	14	58.27	13.23	0.12	2.82	6.10	1.03	3.61	0.17	0.75	5.35	8.28	99.74	5.38	0.25	0.99
01DKA133s	45.48	47.94	15	54.72	16.60	0.10	3.62	3.97	0.60	4.80	0.21	0.83	6.94	7.94	100.34	3.69	0.14	1.88
01DKA133u	47.94	48.76	16	52.28	15.28	0.11	3.20	7.21	0.66	4.28	0.20	0.76	6.28	9.99	100.25	5.95	0.11	1.06
01DKA133v	48.76	51.13	17	51.44	15.00	0.12	3.10	7.69	0.68	4.15	0.18	0.75	6.20	10.49	99.79	6.40	0.10	0.97
01DKA133w	51.13	52.12	18	58.02	12.32	0.13	2.80	7.16	1.13	3.34	0.17	0.68	4.93	9.30	99.98	6.46	0.12	0.76
01DKA133x	52.12	53.37	19	57.13	16.25	0.09	3.37	3.01	0.74	4.72	0.19	0.84	6.67	6.93	99.95	3.00	0.18	2.22
01DKA133y	53.37	56.51	20	50.38	12.61	0.15	2.50	11.66	0.90	3.14	0.16	0.64	5.14	12.50	99.80	9.70	0.12	0.53
01DKA133z	56.51	59.11	21	54.44	15.71	0.12	3.39	5.16	0.78	4.36	0.23	0.81	6.75	8.50	100.25	4.68	0.18	1.44
01DKA133aa	59.11	60.13	22	53.49	12.34	0.16	2.68	9.71	1.01	3.14	0.20	0.67	5.25	11.15	99.79	8.09	0.10	0.65
01DKA133ab	60.13	61.08	23	57.36	16.30	0.10	3.45	2.87	0.85	4.65	0.22	0.88	6.87	6.78	100.33	2.88	0.16	2.39
01DKA134a	2.59	4.68	1, 2	43.77	11.17	0.13	7.49	10.61	0.09	3.76	0.13	0.57	5.06	17.18	99.94	14.80	0.05	0.34
01DKA134b	4.68	7.59	3	43.21	10.36	0.12	7.21	12.24	0.09	3.51	0.13	0.55	4.15	18.05	99.65	15.30	0.14	0.27
01DKA134c	7.59	9.80	4, 5, 6	39.30	9.45	0.12	5.99	16.09	0.23	3.37	0.13	0.47	4.13	19.37	98.65	16.70	0.32	0.25
01DKA134d	9.80	12.24	7	39.72	9.58	0.11	5.34	16.67	0.18	3.48	0.13	0.47	4.21	19.11	99.01	16.30	0.27	0.26
01DKA134e	12.24	14.34	7	45.75	11.93	0.11	4.79	12.23	0.17	3.76	0.16	0.58	4.73	15.38	99.59	12.00	0.20	0.39
01DKA134f	14.34	16.82	8, 9	47.04	11.94	0.11	4.62	11.70	0.20	3.69	0.18	0.59	4.83	14.79	99.69	11.60	0.13	0.42

Sample #	Depth (m)		Litho-logic unit #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S	Fe2O3/ CO2
	From	To																
01DKA134g	16.82	19.35	10	49.82	14.54	0.10	4.52	7.95	0.28	4.41	0.20	0.70	5.80	11.87	100.19	8.07	0.14	0.72
01DKA134h	19.35	21.88	11	51.57	11.37	0.11	3.95	10.46	0.18	3.96	0.19	0.59	4.51	13.02	99.91	10.20	0.13	0.44
01DKA134i	21.88	24.68	12, 13, 14	46.43	10.17	0.12	4.50	13.61	0.17	3.33	0.18	0.52	4.31	16.25	99.61	13.40	0.18	0.32
01DKA134j	24.68	25.78	15	53.34	15.29	0.10	4.10	5.35	0.23	5.05	0.23	0.77	6.15	9.48	100.08	5.73	0.13	1.07
01DKA134k	25.78	28.16	16	52.86	11.35	0.12	4.23	9.11	0.18	4.03	0.18	0.61	4.77	12.36	99.79	9.61	0.21	0.50
01DKA134l	28.16	30.48	17	54.39	15.20	0.10	4.13	4.88	0.24	5.01	0.20	0.79	6.24	9.04	100.23	5.41	0.16	1.15
01DKA134m	30.48	32.56	17, 18	50.26	12.07	0.12	4.34	9.82	0.20	3.97	0.18	0.61	5.13	13.07	99.78	10.10	0.20	0.51
01DKA134n	*32.56*	*35.04*	*19*	*54.51*	*16.01*	*0.10*	*4.12*	*3.97*	*0.22*	*5.33*	*0.21*	*0.81*	*6.45*	*8.36*	*100.08*	*4.49*	*0.13*	*1.44*
01DKA134o	35.04	35.88	20	50.99	11.98	0.12	4.20	9.85	0.15	4.03	0.15	0.63	4.99	13.03	100.13	10.10	0.11	0.49
01DKA134q	35.88	38.48	21	52.53	16.15	0.11	4.27	4.53	0.23	5.22	0.24	0.78	6.67	9.22	99.95	5.10	0.15	1.31
01DKA134r	38.48	39.11	22	52.80	9.46	0.13	3.56	11.70	0.14	3.58	0.16	0.53	3.96	13.68	99.70	11.50	0.10	0.34
01DKA134s	39.11	41.13	23	55.07	15.80	0.09	4.05	3.95	0.23	5.27	0.19	0.82	6.33	8.38	100.18	4.48	0.11	1.41
01DKA134t	41.13	41.87	24	51.83	10.72	0.13	4.07	10.38	0.18	3.82	0.17	0.58	4.64	13.24	99.76	10.70	0.16	0.43
01DKA134u	41.87	44.79	25	56.05	15.37	0.09	3.71	4.29	0.22	5.11	0.19	0.80	6.19	8.15	100.18	5.00	0.20	1.24
01DKA134v	44.79	46.82	25, 26	49.90	11.87	0.13	3.75	10.71	0.21	3.79	0.15	0.63	5.05	13.26	99.46	11.30	0.20	0.45
01DKA134w	46.82	48.74	27	54.38	16.05	0.12	4.26	3.52	0.23	5.32	0.24	0.81	6.78	8.29	99.99	4.42	0.23	1.53
01DKA134x	48.74	51.42	28, 29	56.31	15.52	0.09	3.83	2.98	0.24	5.41	0.21	0.84	6.37	7.36	99.17	3.52	0.20	1.81
01DKA134y	51.42	52.32	30	36.54	7.86	0.22	6.19	16.95	0.23	2.87	0.17	0.42	6.39	19.40	97.26	18.20	1.16	0.35
01DKA134z	52.32	54.07	31	53.94	16.04	0.11	4.00	4.13	0.24	5.22	0.25	0.83	6.74	8.58	100.08	4.47	0.25	1.51
01DKA134aa	54.07	56.14	31	57.96	15.46	0.08	3.63	3.15	0.26	5.23	0.20	0.85	6.15	7.21	100.18	3.56	0.21	1.73
01DKA134ab	56.14	58.47	32	52.82	11.44	0.13	3.68	9.43	0.30	4.05	0.19	0.60	4.98	11.57	99.19	9.42	0.42	0.53
01DKA134ac	58.47	61.27	33	54.61	14.93	0.11	3.65	5.41	0.29	5.03	0.23	0.76	6.06	8.81	99.87	5.46	0.28	1.11
		detection limits		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	n/a	0.03	0.01	n/a
		units		wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	n/a

Table 6-10: Trace and minor element data for drill core bed samples from OGS-01-06 (station 01DKA-035). All data reported in part per million, except Au and Ag which are reported in oz/tonne; n.d. = not detected; n.m. = not measured. All elements analyzed by ICP-MS, except As by ICP-AES and Au and Ag by gravimetric fire assay. Analytical detection limits are listed at bottom of table.

Sample #	As	Al	Ba	Be	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd
01DKA035a	n.d.	83787.8	350.53	2.98	32207.2	n.d.	87.52	18.20	79.00	6.58	11.72	5.11	2.80	1.49	58790.3	20.89	6.17
01DKA035b	n.d.	89394.8	515.43	2.36	34115.2	n.d.	88.06	17.82	84.40	6.56	12.43	4.92	2.79	1.40	57248.2	21.05	6.02
01DKA035c	n.d.	79851.4	392.61	2.78	41871.3	n.d.	72.06	15.29	72.81	5.21	14.85	4.80	2.66	1.40	36141.7	17.95	5.83
01DKA035d	n.d.	91113.4	498.64	2.80	30350.6	n.d.	87.32	18.35	85.01	6.60	12.70	4.71	2.63	1.41	62612.5	20.75	5.96
01DKA035e	n.m.	89251.6	451.14	2.49	25605.1	n.d.	89.36	18.30	79.67	6.83	12.02	4.88	2.80	1.42	59784.2	21.26	6.07
01DKA035f	n.d.	87500.9	518.51	2.20	24960.2	n.d.	93.56	18.44	105.26	6.66	11.99	4.76	2.68	1.51	64049.9	20.79	5.83
01DKA035g	n.d.	83542.9	397.14	2.41	40218.8	n.d.	90.20	17.95	105.56	6.10	13.49	4.90	2.58	1.47	58389.2	20.05	6.11
01DKA035h	n.d.	91986.5	379.08	2.38	44666.5	n.d.	98.18	19.15	125.61	6.97	12.90	4.80	2.77	1.48	64225.3	21.72	6.00
01DKA035i	4.62	88269.2	502.00	2.47	26195.1	n.d.	93.18	18.32	102.31	6.76	11.63	4.87	2.67	1.40	63097.4	21.60	5.87
01DKA035j	n.m.	85679.0	492.84	2.60	27993.9	n.d.	95.16	18.76	100.34	6.93	14.96	4.60	2.63	1.43	65744.6	22.35	5.90
01DKA035k	n.d.	68548.0	359.00	n.d.	42843.4	n.d.	76.09	14.78	80.72	4.81	12.06	4.68	2.49	1.39	44919.5	17.23	5.68
01DKA035l	n.d.	75552.1	426.59	n.d.	37674.0	n.d.	88.90	17.14	98.97	5.99	14.26	4.80	2.82	1.45	53977.9	20.12	5.93
01DKA035m	n.d.	72062.7	315.71	2.42	41671.8	n.d.	82.95	15.25	78.16	5.60	13.34	4.73	2.55	1.40	43460.4	17.73	5.86
01DKA035n	n.d.	78839.6	378.71	2.22	38050.2	n.d.	89.76	16.75	83.75	6.18	16.53	4.40	2.63	1.38	54191.5	19.42	5.87
01DKA035o	n.d.	78718.4	373.32	2.12	27765.8	n.d.	94.31	16.89	94.65	6.26	20.10	4.78	2.85	1.37	54173.5	19.98	5.84
01DKA035p	n.d.	84698.9	478.60	2.91	18835.6	n.d.	95.95	17.46	91.70	7.06	18.49	4.44	2.70	1.33	63885.8	21.78	5.42
01DKA035q	n.d.	56184.2	447.07	n.d.	45121.9	n.d.	73.77	13.50	67.46	3.44	41.55	4.73	2.59	1.54	62899.1	13.51	6.17
01DKA035r	n.d.	65644.7	260.08	n.d.	39504.3	n.d.	87.50	15.41	78.53	5.11	28.47	4.62	2.67	1.29	45381.1	17.14	5.67
01DKA035s	n.m.	16333.8	75.87	n.d.	>280000.00	n.d.	45.26	5.24	33.66	1.08	9.51	3.73	1.88	1.11	21904.0	4.52	4.40
01DKA035t	n.d.	79435.6	315.59	2.03	15985.9	n.d.	102.26	18.00	90.14	7.29	24.66	4.34	2.51	1.30	63472.1	20.85	5.22
01DKA035u	14.30	55569.1	194.35	2.05	76969.4	n.d.	74.56	18.08	63.13	3.56	>1000.00	4.12	2.28	1.12	40578.1	13.21	4.76

Sample #	As	Al	Ba	Be	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd
01DKA035v	11.56	7317.1	28.28	n.d.	>280000.00	n.d.	37.73	7.20	27.38	0.62	163.15	4.06	1.93	1.21	12715.2	1.97	4.87
01DKA035w	7.73	27541.4	488.34	n.d.	196589.0	n.d.	54.60	11.12	29.94	2.12	25.54	4.05	2.06	1.20	30607.8	7.48	5.06
01DKA035x	n.d.	63451.2	386.57	n.d.	45725.0	n.d.	82.14	14.81	58.38	4.96	30.14	4.40	2.40	1.30	47025.8	16.77	5.17
01DKA035y	n.d.	17093.9	103.68	n.d.	>280000.00	n.d.	64.34	5.73	22.94	1.31	119.27	6.16	2.83	1.83	18373.3	4.70	7.62
01DKA035z	8.78	66241.0	314.48	n.d.	33166.3	n.d.	95.00	16.75	64.68	5.68	11.25	4.88	2.70	1.42	48082.9	17.67	6.06
01DKA035aa	n.d.	78890.7	292.31	n.d.	29504.5	n.d.	104.69	17.24	79.70	6.68	6.86	4.50	2.54	1.30	54641.7	19.48	5.36
01DKA035ab	n.d.	42307.4	189.08	n.d.	134188.0	n.d.	76.24	10.34	45.76	2.91	220.40	4.60	2.45	1.41	35314.2	10.76	5.57
01DKA035ac	n.d.	82339.7	319.09	2.17	32053.8	n.d.	126.01	18.17	91.64	7.32	26.24	4.71	2.75	1.40	59059.7	20.98	5.63
01DKA035ad	14.86	78988.6	284.34	2.31	49148.9	n.d.	81.57	19.91	46.96	6.14	32.92	4.50	2.58	1.30	48162.4	20.25	5.26
01DKA035ae	n.m.	89424.2	396.60	3.18	19135.3	n.d.	82.99	18.70	98.07	7.03	52.67	4.74	2.82	1.35	53508.0	22.21	5.95
01DKA035af	n.d.	81250.5	285.47	2.15	41679.4	n.d.	80.31	16.48	88.90	6.86	88.38	4.48	2.63	1.38	48892.3	20.11	5.56
01DKA035ag	n.d.	29751.5	411.94	n.d.	178183.0	n.d.	42.90	15.11	50.54	1.90	53.96	3.65	1.88	1.12	52980.3	7.44	4.34
01DKA035ah	n.d.	89625.5	415.08	2.78	27494.7	n.d.	88.39	17.13	98.21	7.37	66.63	4.58	2.67	1.27	50494.6	21.09	5.38
01DKA035ai	n.d.	63955.1	281.38	n.d.	81544.3	n.d.	64.27	12.96	70.30	4.81	119.46	4.44	2.51	1.29	38108.4	16.47	5.23
01DKA035aj	n.d.	8207.9	231.90	n.d.	>280000.00	n.d.	17.24	24.20	33.20	0.65	16.08	1.75	0.79	0.53	57998.6	2.20	2.14
01DKA035ak	n.d.	63125.3	261.12	2.33	65990.7	n.d.	71.03	12.46	71.57	5.34	32.67	4.76	2.72	1.36	39860.4	16.99	5.83
01DKA035al	n.d.	87849.8	614.53	2.79	18809.8	n.d.	87.83	17.44	96.88	7.52	13.31	4.38	2.48	1.30	48800.0	22.50	5.19
01DKA035am	7.08	91412.5	358.64	2.87	22853.0	n.d.	96.02	19.48	93.95	7.93	45.95	4.93	2.98	1.45	55679.3	23.46	5.82
01DKA035an	n.d.	61947.8	206.52	2.12	63690.1	n.d.	67.10	10.31	64.57	3.80	128.53	5.49	2.79	1.57	38223.4	13.81	6.44
01DKA035ao	6.58	89668.8	298.84	2.28	39836.4	n.d.	93.01	19.66	81.80	6.66	33.50	5.52	2.88	1.48	57090.1	20.42	6.50
01DKA035ap	n.d.	94049.5	320.16	2.85	23483.4	n.d.	89.00	19.25	86.63	7.06	45.18	4.86	2.62	1.36	58186.8	21.97	5.68
detection limits:	4.5	100.0	5.00	2.00	100.0	1	0.20	1.00	1.00	0.10	2.00	0.30	0.05	0.20	5.0	1.00	0.30

Sample #	Hf	Ho	La	Li	Lu	Mg	Mn	Mo	Nb	n.d.	Ni	Pb	Pr	Rb	Sb	Sc	Sm	Sn
01DKA035a	3.72	1.12	43.03	49.79	0.42	17765.1	742.19	4.31	14.43	39.67	61.37	13.79	10.50	136.18	0.69	14.72	7.01	2.48
01DKA035b	3.70	1.03	40.17	50.93	0.40	19282.6	779.82	2.51	14.49	38.50	47.91	12.90	10.00	141.95	0.60	14.83	7.01	2.60
01DKA035c	3.78	0.98	33.02	44.65	0.40	16622.9	962.63	1.27	13.42	33.61	39.30	7.39	8.77	114.42	n.d.	13.06	6.68	2.24
01DKA035d	3.38	1.02	39.52	51.75	0.41	19680.2	738.85	2.17	14.61	36.07	48.40	13.61	9.61	136.99	0.63	15.08	6.73	3.24
01DKA035e	3.75	1.04	40.86	51.57	0.44	19485.1	609.50	2.37	14.37	39.00	47.65	14.06	10.38	140.41	0.66	15.17	6.98	2.74
01DKA035f	3.56	1.04	41.25	47.36	0.41	18878.8	666.60	2.10	13.91	38.18	47.22	12.92	10.39	137.95	0.61	14.68	6.91	2.58
01DKA035g	3.48	1.03	38.34	44.95	0.38	18323.8	943.57	2.23	13.50	35.86	46.52	14.13	9.50	129.61	0.58	14.68	6.93	2.68
01DKA035h	3.49	1.04	40.80	51.31	0.42	20325.9	829.39	2.33	14.97	37.57	50.78	13.28	10.15	92.43	0.60	16.12	7.13	2.72
01DKA035i	3.99	1.04	39.84	46.91	0.41	19355.6	639.80	2.42	14.95	36.29	46.94	15.46	9.72	100.91	0.65	15.71	6.88	2.68
01DKA035j	3.52	0.98	40.22	49.10	0.41	19554.8	692.31	1.92	14.24	36.59	48.84	14.21	9.90	144.91	0.59	15.42	6.88	2.78
01DKA035k	3.93	1.02	32.40	40.97	0.38	15245.5	1026.52	1.20	13.80	34.55	37.46	10.74	8.66	108.74	n.d.	12.35	6.61	2.08
01DKA035l	4.07	1.02	38.11	43.86	0.42	17446.1	904.39	2.65	14.54	35.72	42.74	12.37	9.62	129.98	0.52	14.57	6.85	2.53
01DKA035m	3.45	1.00	35.09	41.75	0.38	16809.4	1054.41	1.48	13.27	34.13	40.62	8.92	8.92	118.14	n.d.	12.77	6.60	2.27
01DKA035n	3.48	0.97	37.62	40.04	0.37	17978.9	1052.89	2.27	13.60	35.68	42.34	11.60	9.29	130.76	n.d.	14.64	6.44	2.36
01DKA035o	3.77	1.01	36.83	42.49	0.41	18632.8	738.83	1.84	14.20	34.53	45.89	9.04	9.33	132.49	n.d.	14.36	6.57	2.46
01DKA035p	3.86	1.02	39.42	43.82	0.42	19304.0	593.30	2.33	15.90	34.28	48.07	11.48	9.43	145.88	0.61	15.84	6.43	2.61
01DKA035q	3.99	1.00	27.84	38.55	0.38	18026.0	1356.64	2.02	11.52	32.28	32.85	6.05	7.94	78.28	n.d.	10.12	6.88	1.68
01DKA035r	4.05	0.96	34.16	39.95	0.39	17220.7	976.44	1.61	13.50	32.35	41.86	6.39	8.60	108.70	n.d.	12.71	6.32	2.08
01DKA035s	1.59	0.77	15.56	12.18	0.23	17893.7	>2500.00	1.20	3.72	19.49	11.95	8.63	4.79	24.05	n.d.	3.84	4.38	0.50
01DKA035t	3.79	0.92	39.83	47.23	0.40	20203.7	570.75	2.01	15.05	35.23	52.14	6.34	9.63	144.31	0.54	15.36	6.08	2.75
01DKA035u	3.49	0.89	27.56	36.32	0.35	21055.9	1925.73	1.27	10.74	25.78	32.45	9.47	6.91	78.41	n.d.	9.46	5.04	1.79

Sample #	Hf	Ho	La	Li	Lu	Mg	Mn	Mo	Nb	n.d.	Ni	Pb	Pr	Rb	Sb	Sc	Sm
01DKA035v	0.41	0.80	12.26	5.80	0.22	16417.6	>2500.00	n.d.	1.44	18.02	7.02	4.67	4.01	12.21	n.d.	3.53	4.58
01DKA035w	2.50	0.81	20.62	19.48	0.29	32264.8	>2500.00	n.d.	5.88	24.08	18.36	7.84	6.02	46.70	n.d.	6.17	5.36
01DKA035x	3.10	0.88	31.67	44.04	0.34	22830.9	1316.12	n.d.	12.18	29.97	41.25	4.05	8.03	102.93	n.d.	12.55	5.72
01DKA035y	1.27	1.19	20.84	12.36	0.34	8742.2	>2500.00	n.d.	3.60	29.38	13.65	4.02	6.68	26.31	n.d.	6.44	7.38
01DKA035z	3.42	0.98	36.64	45.30	0.41	20823.9	1141.23	n.d.	12.83	34.04	42.32	5.23	9.15	111.76	n.d.	12.66	6.27
01DKA035aa	3.55	0.94	38.07	48.56	0.38	23292.0	1032.28	n.d.	13.75	34.17	48.74	4.60	9.42	127.91	n.d.	13.90	6.26
01DKA035ab	3.99	0.99	26.16	28.01	0.34	15612.4	1882.43	n.d.	9.16	30.19	27.59	3.20	7.60	62.56	n.d.	8.19	6.48
01DKA035ac	3.62	0.98	43.01	47.80	0.38	23317.6	977.83	n.d.	15.39	36.45	53.86	5.11	9.92	138.69	n.d.	14.85	6.48
01DKA035ad	3.49	0.92	37.30	51.33	0.39	20337.2	792.04	14.19	13.68	33.63	42.55	18.45	9.24	128.13	0.59	13.67	6.23
01DKA035ae	3.99	1.04	40.84	60.89	0.45	21575.4	539.37	1.52	15.85	38.07	44.86	13.54	10.14	147.82	n.d.	16.02	6.83
01DKA035af	3.60	0.95	39.26	54.08	0.40	23406.2	901.17	n.d.	14.08	35.60	42.30	9.41	9.53	136.25	n.d.	14.93	6.58
01DKA035ag	2.64	0.75	19.39	22.39	0.24	11959.8	1705.13	10.78	6.59	22.18	26.03	20.54	5.44	41.50	n.d.	5.62	4.69
01DKA035ah	3.52	0.92	41.31	57.76	0.40	22937.8	643.80	n.d.	15.02	37.28	45.31	8.42	9.92	148.61	n.d.	15.47	6.33
01DKA035ai	3.31	0.90	31.95	42.71	0.34	16362.6	924.68	n.d.	12.52	31.45	32.36	6.20	8.26	105.86	n.d.	11.75	6.21
01DKA035aj	0.44	0.34	7.22	7.48	0.08	7444.9	1966.00	4.00	1.58	9.36	31.18	26.11	2.29	13.41	n.d.	2.26	2.21
01DKA035ak	3.94	1.06	34.98	46.76	0.41	16059.7	921.48	n.d.	13.27	34.31	33.13	5.33	9.26	112.14	n.d.	13.29	6.83
01DKA035al	3.84	0.93	42.73	58.39	0.36	20096.2	557.45	n.d.	15.08	34.68	47.07	10.04	9.98	154.23	n.d.	15.41	6.02
01DKA035am	3.85	1.05	43.75	63.46	0.45	21857.1	630.90	n.d.	15.79	39.44	50.19	10.09	10.79	161.03	n.d.	17.16	6.93
01DKA035an	3.87	1.12	27.55	47.29	0.41	15446.9	1291.89	n.d.	11.17	33.68	30.22	5.23	8.20	81.44	n.d.	11.06	7.07
01DKA035ao	3.87	1.10	41.44	56.70	0.45	20861.1	906.38	n.d.	16.41	38.95	44.75	11.83	10.49	134.57	n.d.	14.85	7.48
01DKA035ap	3.44	0.99	40.26	59.02	0.38	20790.5	634.47	n.d.	15.08	35.98	47.79	9.67	9.92	145.36	n.d.	15.72	6.85
detection limits:	0.01	0.20	0.20	1.00	0.01	20.0	0.10	1.00	0.02	0.50	5.00	0.10	0.20	1.00	0.50	0.50	0.50

Sample #	Sn	Sr	Ta	Tb	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn	Zr	Ag	Au
01DKA035a	2.48	118.30	0.96	0.92	11.75	4196.39	0.84	0.41	2.99	117.07	1.19	29.83	2.69	117.13	132.57	n.d.	n.d.
01DKA035b	2.60	141.11	1.01	0.94	11.88	4552.52	0.81	0.44	3.26	130.57	1.10	29.84	2.82	89.71	125.65	n.d.	n.d.
01DKA035c	2.24	151.48	0.90	0.90	10.20	4189.99	0.68	0.40	2.86	149.94	0.96	28.88	2.65	77.41	129.71	n.d.	n.d.
01DKA035d	3.24	169.71	0.98	0.86	11.28	4750.98	0.83	0.41	3.19	146.69	1.52	28.02	2.72	82.33	116.08	n.d.	n.d.
01DKA035e	2.74	158.51	1.04	0.90	11.92	4629.09	0.83	0.44	3.42	130.25	1.49	28.67	2.83	88.51	129.53	n.d.	n.d.
01DKA035f	2.58	182.32	0.98	0.92	11.69	4667.74	0.76	0.41	3.25	131.86	1.08	28.33	2.84	81.27	122.68	n.d.	n.d.
01DKA035g	2.68	181.98	0.95	0.91	10.75	4693.64	0.73	0.41	3.02	132.77	1.09	27.73	2.78	84.88	120.34	n.d.	n.d.
01DKA035h	2.72	178.99	1.00	0.92	11.19	5180.59	0.80	0.41	4.07	161.75	1.10	28.92	2.81	87.61	119.18	n.d.	n.d.
01DKA035i	2.68	170.41	1.09	0.89	12.09	4955.11	0.79	0.42	3.50	141.56	1.02	28.67	2.92	86.89	136.43	n.d.	n.d.
01DKA035j	2.78	162.32	0.97	0.87	11.58	4883.56	0.80	0.39	4.05	167.53	1.03	27.77	2.59	86.97	122.70	n.d.	n.d.
01DKA035k	2.08	136.51	0.94	0.89	10.11	4384.53	0.60	0.40	3.22	116.75	0.76	28.46	2.77	74.08	142.87	n.d.	n.d.
01DKA035l	2.53	137.16	0.93	0.92	11.11	4510.69	0.66	0.42	3.53	120.93	0.94	29.26	2.79	78.53	145.83	n.d.	n.d.
01DKA035m	2.27	129.89	0.88	0.86	10.27	4261.96	0.72	0.38	3.01	122.72	0.81	26.67	2.66	72.51	121.35	n.d.	n.d.
01DKA035n	2.36	124.92	0.89	0.89	10.73	4541.89	0.68	0.41	2.93	126.90	0.90	27.80	2.56	73.77	127.23	n.d.	n.d.
01DKA035o	2.46	122.98	0.93	0.90	11.38	4801.15	0.70	0.38	3.20	144.78	0.82	27.16	2.78	77.73	129.93	n.d.	n.d.
01DKA035p	2.61	134.16	1.06	0.82	11.93	5078.34	0.75	0.40	3.57	149.46	0.91	26.85	2.58	81.89	137.46	n.d.	n.d.
01DKA035q	1.68	173.04	0.78	0.90	8.92	3938.50	0.42	0.38	3.10	128.21	0.68	28.67	2.66	61.62	131.02	n.d.	n.d.
01DKA035r	2.08	118.98	0.97	0.87	10.77	4707.33	0.60	0.42	3.40	119.75	0.77	26.80	2.69	72.10	141.58	n.d.	n.d.
01DKA035s	0.50	413.92	n.d.	0.69	3.53	1235.05	n.d.	n.d.	1.09	34.07	0.11	22.12	1.60	27.16	58.10	0.3	n.d.
01DKA035t	2.75	95.61	1.00	0.78	12.67	5291.17	0.73	0.40	3.77	153.84	0.97	24.02	2.55	82.56	135.73	0.5	n.d.
01DKA035u	1.79	139.08	0.72	0.77	8.42	3854.99	0.76	0.35	3.17	100.04	0.61	23.46	2.41	59.74	125.92	0.1	n.d.

Sample #	Sn	Sr	Ta	Tb	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn	Zr	Ag	Au
01DKA035v	0.25	344.52	n.d.	0.79	2.38	498.50	n.d.	n.d.	0.57	21.80	n.d.	24.78	1.59	11.25	15.25	n.d.	n.d.
01DKA035w	0.92	366.01	n.d.	0.75	5.43	1830.32	0.32	n.d.	1.68	54.39	0.17	23.68	1.94	37.24	90.10	n.d.	n.d.
01DKA035x	2.02	135.36	0.84	0.79	10.04	4271.77	0.55	0.34	2.74	120.75	0.71	24.69	2.39	66.51	108.45	n.d.	n.d.
01DKA035y	0.62	328.52	n.d.	1.14	5.64	1264.55	n.d.	0.40	0.99	41.31	n.d.	33.22	2.51	34.11	48.64	0.5	n.d.
01DKA035z	2.13	121.05	0.92	0.87	10.90	4543.68	0.62	0.41	3.27	130.63	0.69	26.58	2.68	70.70	121.15	n.d.	n.d.
01DKA035aa	2.60	123.96	0.95	0.83	11.11	5082.13	0.66	0.39	3.24	144.73	0.87	25.24	2.56	75.80	114.77	n.d.	n.d.
01DKA035ab	1.23	212.10	0.61	0.87	7.44	3242.39	0.37	0.39	2.22	78.29	0.50	26.84	2.57	76.10	138.55	n.d.	n.d.
01DKA035ac	2.65	136.18	1.02	0.83	12.17	6023.15	0.74	0.39	3.52	168.31	0.80	26.71	2.70	79.53	127.53	n.d.	n.d.
01DKA035ad	2.38	151.75	0.95	0.79	10.74	4301.40	0.79	0.38	3.45	129.37	0.82	25.09	2.53	77.48	116.73	n.d.	n.d.
01DKA035ae	2.63	122.70	1.08	0.90	12.98	4529.97	0.76	0.42	3.73	135.39	1.20	27.64	2.80	82.69	140.44	n.d.	n.d.
01DKA035af	2.43	139.19	0.99	0.85	11.31	4028.12	0.66	0.39	3.01	128.32	1.09	26.02	2.58	79.54	116.02	n.d.	n.d.
01DKA035ag	0.83	273.33	n.d.	0.66	5.27	1840.77	0.76	n.d.	1.71	44.71	0.50	21.14	1.72	38.94	92.08	n.d.	n.d.
01DKA035ah	2.74	145.34	1.02	0.84	11.87	4471.77	0.69	0.39	3.17	138.02	1.13	26.46	2.68	81.08	126.23	n.d.	n.d.
01DKA035ai	2.01	194.38	0.84	0.82	9.32	3488.70	0.50	0.36	2.57	97.17	0.88	25.80	2.47	76.74	114.86	n.d.	n.d.
01DKA035aj	0.27	492.48	n.d.	n.d.	1.46	454.24	n.d.	n.d.	0.55	15.65	0.11	9.62	0.67	14.75	16.98	0.8	n.d.
01DKA035ak	2.12	184.40	0.91	0.88	10.66	3604.59	0.54	0.42	3.18	102.81	0.99	29.32	2.91	65.66	138.21	n.d.	n.d.
01DKA035al	2.67	157.47	1.06	0.75	12.64	4596.84	0.69	0.40	3.69	143.54	1.19	25.30	2.71	80.92	136.66	0.3	n.d.
01DKA035am	2.96	145.36	1.12	0.93	13.16	4753.58	0.82	0.43	3.85	151.27	1.23	29.01	3.00	85.17	133.84	n.d.	n.d.
01DKA035an	1.64	144.18	0.84	1.02	8.88	3738.29	0.41	0.41	2.55	90.40	1.04	30.03	2.77	57.34	135.38	0.7	n.d.
01DKA035ao	2.65	156.09	1.13	0.98	12.23	4605.20	0.68	0.46	3.26	129.87	1.11	31.09	3.10	78.48	132.55	n.d.	n.d.
01DKA035ap	2.61	136.38	1.04	0.86	11.63	4821.48	0.68	0.39	3.32	142.86	1.18	27.52	2.64	80.81	124.34	n.d.	n.d.
detection limits:	0.10	2.00	0.50	0.50	0.50	10.00	0.30	0.30	0.03	1.00	0.05	0.05	0.50	5.00	1.00	0.1	0.01

Table 6-11 : Trace and minor element data for drill core bed samples from OGS-00-C1 (station 00DKA-053). Drill hole and sample information reported in Armstrong (2001a, 2001b). All data reported in part per million, except Au and Ag which are reported in oz/tonne; n.d. = not detected; n.m. = not measured. All elements analyzed by ICP-MS, except As by ICP-AES and Au and Ag by gravimetric fire assay. Analytical detection limits are listed at bottom of table.

Sample #	As	Al	Ba	Be	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe
00DKA053a	n.d.	41148.70	201.44	n.d.	70124.30	n.d.	67.14	10.57	21.75	2.70	39.58	5.64	3.000	1.380	19341.90
00DKA053b	n.d.	68557.50	293.85	2.30	80375.30	n.d.	65.86	11.53	52.49	6.36	10.53	4.17	2.500	1.100	45670.00
00DKA053c	n.d.	65758.80	280.86	2.09	99568.10	n.d.	63.42	11.80	47.72	5.88	10.92	3.96	2.290	1.070	43475.80
00DKA053d	n.d.	66102.00	271.97	2.20	109522.00	n.d.	62.45	12.12	45.00	5.78	10.64	3.85	2.200	1.000	42854.10
00DKA053e	n.d.	64988.50	257.62	2.00	119704.00	n.d.	61.21	11.74	49.64	5.40	9.40	3.86	2.170	1.010	43104.10
00DKA053f	n.d.	69426.50	276.59	2.43	107448.00	n.d.	62.24	12.96	55.60	6.32	10.04	3.96	2.270	1.070	46596.40
00DKA053g	n.d.	86525.70	355.52	2.78	42437.50	n.d.	70.85	15.69	65.76	7.53	10.76	4.08	2.450	1.080	59500.20
00DKA053h	n.d.	83461.00	321.98	2.82	64158.90	n.d.	69.38	15.07	58.53	7.00	10.63	4.23	2.410	1.110	57937.20
00DKA053i	n.d.	77476.20	309.81	2.66	56488.20	n.d.	66.55	15.27	57.18	7.01	11.86	3.96	2.280	1.030	51642.60
00DKA053j	n.d.	71964.60	277.92	2.20	83639.90	n.d.	64.24	13.81	51.84	6.14	9.46	4.08	2.240	1.050	50282.70
00DKA053k	n.d.	76596.70	288.02	2.54	82319.60	n.d.	64.09	14.48	59.38	6.48	12.55	3.83	2.340	1.080	54902.90
00DKA053l	n.d.	80925.30	299.83	2.76	69409.80	n.d.	62.72	15.20	58.57	6.98	11.16	3.94	2.280	1.000	60399.50
00DKA053m	n.d.	54371.50	212.77	n.d.	170538.00	n.d.	51.70	10.95	41.86	4.51	14.98	3.22	1.760	0.840	29600.90
00DKA053n	n.d.	73628.60	274.33	2.25	90901.80	n.d.	60.01	14.07	53.18	6.16	10.95	3.74	2.060	0.950	55448.90
00DKA053o	n.d.	8166.31	47.63	n.d.	> 280000.00	n.d.	15.33	2.82	n.d.	0.78	9.37	1.10	0.500	0.300	6772.07
00DKA053p	n.d.	63462.10	268.43	2.29	116172.00	n.d.	55.41	14.46	47.21	5.78	53.16	3.34	2.050	0.950	33930.70
00DKA053q	n.d.	41480.80	258.21	n.d.	137633.00	n.d.	50.82	8.24	31.91	2.48	40.86	4.19	2.160	1.060	23762.30
00DKA053r	n.d.	52971.40	221.60	n.d.	118234.00	n.d.	51.66	13.84	43.49	4.75	39.61	3.42	1.860	0.910	31677.50
00DKA053s	n.d.	61117.30	258.71	2.16	81004.00	n.d.	55.12	12.63	44.60	5.59	15.96	3.50	2.040	0.960	42375.20
00DKA053t	n.d.	48310.30	196.62	n.d.	111568.00	n.d.	45.62	10.75	37.83	4.71	10.88	2.87	1.660	0.780	29161.30
00DKA053u	n.d.	47101.50	355.50	n.d.	100374.00	n.d.	53.14	10.51	30.90	4.23	21.12	3.87	2.230	1.000	30756.90
00DKA053v	n.d.	57475.20	245.69	n.d.	89052.20	n.d.	57.32	12.12	42.05	5.35	50.30	3.75	2.190	0.990	39319.30
00DKA053w	n.d.	63926.10	289.66	2.21	74883.10	n.d.	63.60	12.83	45.31	5.57	13.24	4.21	2.440	1.070	34959.30
00DKA053x	n.d.	66602.20	312.94	2.03	63940.40	n.d.	62.29	12.81	45.31	5.48	11.69	4.37	2.540	1.160	52758.40
00DKA053y	n.d.	67078.00	330.76	2.14	47489.70	n.d.	67.57	12.37	43.04	5.48	29.22	4.85	2.890	1.200	52464.90
00DKA053z	n.d.	43165.30	259.90	n.d.	123326.00	n.d.	49.46	17.80	28.02	2.82	48.22	4.04	2.220	1.040	27039.20
detection limits:	4.90	100.00	5.00	2.00	100.00	1.00	0.30	1.00	1.00	0.01	2.00	0.01	0.006	0.004	5.00

Sample #	Ga	Gd	Hf	Ho	La	Li	Lu	Mg	Mn	Mo	Nb	n.d.	Ni	Pb	Pr	Rb	Sb	Sc
00DKA053a	9.79	6.14	5.52	1.110	30.11	40.95	0.433	33291.40	510.09	1.18	12.95	32.62	21.63	6.86	8.71	76.79	n.d.	7.40
00DKA053b	17.06	4.61	3.32	0.860	33.49	58.00	0.384	26256.20	487.16	n.d.	12.96	29.14	31.57	8.21	8.07	126.66	n.d.	12.90
00DKA053c	16.12	4.51	3.14	0.830	31.98	54.57	0.333	25441.40	514.56	n.d.	12.22	27.97	31.68	8.43	7.80	123.84	n.d.	11.99
00DKA053d	15.82	4.43	2.96	0.770	31.49	56.61	0.335	24150.20	511.76	n.d.	11.94	27.44	32.76	8.46	7.62	127.25	n.d.	11.92
00DKA053e	15.52	4.40	3.21	0.780	31.12	55.88	0.337	25352.00	539.62	n.d.	11.39	26.57	32.34	8.40	7.46	122.75	n.d.	11.97
00DKA053f	17.45	4.48	2.82	0.800	32.35	59.70	0.352	20320.30	558.30	n.d.	11.82	28.13	35.72	7.61	7.68	128.72	n.d.	13.08
00DKA053g	21.15	4.50	3.16	0.830	36.17	70.15	0.376	20269.50	434.38	n.d.	15.18	31.31	39.84	8.66	8.69	156.25	0.65	14.97
00DKA053h	19.58	4.69	2.89	0.860	35.25	71.47	0.364	26823.80	560.73	n.d.	13.76	31.02	37.19	8.66	8.62	147.23	0.57	14.56
00DKA053i	18.98	4.34	3.00	0.810	33.69	64.15	0.331	27288.00	543.22	n.d.	14.10	28.52	37.40	8.69	8.05	149.15	0.57	12.63
00DKA053j	17.55	4.43	3.00	0.810	32.26	58.23	0.336	28704.70	591.99	n.d.	12.77	28.16	33.56	8.11	7.89	128.06	0.53	13.06
00DKA053k	18.03	4.31	2.97	0.790	32.42	65.47	0.357	29986.90	618.55	n.d.	12.63	29.46	35.56	7.97	8.11	133.18	0.55	13.94
00DKA053l	18.66	4.30	2.89	0.810	32.18	69.81	0.345	24512.40	529.43	n.d.	13.36	28.07	35.48	7.52	7.70	143.28	0.60	14.53
00DKA053m	12.68	3.68	2.31	0.640	25.64	48.32	0.261	18186.60	739.57	n.d.	9.71	22.56	31.51	8.13	6.25	104.47	n.d.	9.98
00DKA053n	17.25	4.13	2.86	0.740	31.12	59.13	0.318	30304.60	645.20	1.08	11.84	25.73	34.48	6.14	7.12	132.69	0.62	13.00
00DKA053o	2.34	1.39	0.24	0.200	7.62	8.82	0.055	18889.90	801.72	n.d.	1.39	7.00	19.73	1.05	1.87	18.38	n.d.	1.61
00DKA053p	16.66	3.91	2.60	0.690	28.53	58.65	0.302	23129.30	620.76	n.d.	11.09	25.33	33.08	4.22	6.85	122.63	n.d.	12.48
00DKA053q	8.80	4.78	3.49	0.820	23.90	34.78	0.295	16350.60	535.28	n.d.	10.59	24.14	24.63	3.51	6.43	67.76	n.d.	7.18
00DKA053r	13.41	3.82	3.10	0.660	26.23	46.94	0.283	36004.30	707.95	n.d.	9.98	22.23	31.04	3.54	6.14	103.99	n.d.	9.83
00DKA053s	15.38	3.90	2.80	0.710	28.19	49.28	0.326	38423.80	632.78	n.d.	11.32	24.63	32.49	4.81	6.70	113.96	0.51	11.44
00DKA053t	12.48	3.37	2.47	0.570	23.72	38.82	0.246	35417.00	578.28	n.d.	9.10	19.81	29.16	4.41	5.39	96.22	n.d.	9.44
00DKA053u	12.17	4.34	3.95	0.790	26.13	41.58	0.329	45929.00	747.54	n.d.	10.80	24.62	27.25	4.93	6.58	91.66	n.d.	9.20
00DKA053v	14.85	4.18	3.03	0.770	29.16	48.86	0.324	34374.30	620.54	n.d.	11.43	25.74	32.69	5.80	7.20	113.53	0.54	11.38
00DKA053w	16.22	4.77	4.17	0.880	32.33	56.25	0.368	33387.10	651.27	n.d.	13.26	28.25	33.92	4.22	7.76	125.77	n.d.	11.57
00DKA053x	16.21	4.75	4.15	0.890	30.91	53.82	0.396	28043.50	640.91	n.d.	13.53	28.78	33.05	5.21	7.83	114.22	0.61	11.77
00DKA053y	16.14	5.23	4.90	1.010	33.25	52.99	0.416	28087.60	583.70	n.d.	14.88	30.31	31.93	5.04	8.42	128.06	0.58	11.93
00DKA053z	9.31	4.62	5.66	0.800	23.82	33.40	0.329	34689.20	851.06	1.49	9.58	23.15	29.21	7.29	6.16	70.55	n.d.	7.33
detection limits	1.00	0.03	0.10	0.002	0.20	1.00	0.001	20.00	0.10	1.00	0.08	0.20	5.00	0.10	0.03	0.20	0.50	0.50

Sample #	Sm	Sn	Sr	Ta	Tb	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn	Zr	Ag	Au
00DKA053a	6.81	1.34	122.34	0.75	0.970	8.42	2932.84	0.48	0.440	2.69	53.31	0.92	30.78	2.70	37.03	216.93	n.d.	n.d.
00DKA053b	5.67	2.23	156.08	0.80	0.720	9.54	3089.45	0.66	0.390	2.41	99.79	1.09	21.10	2.42	56.56	112.44	n.d.	n.d.
00DKA053c	5.22	2.08	160.00	0.75	0.680	8.81	2966.51	0.68	0.350	2.41	93.44	0.93	21.00	2.20	53.80	112.85	n.d.	n.d.
00DKA053d	5.09	2.10	181.31	0.72	0.660	8.44	2935.05	0.61	0.340	2.37	89.94	0.95	21.17	2.10	53.28	108.32	n.d.	n.d.
00DKA053e	5.02	1.95	189.31	0.70	0.670	7.90	2892.98	0.57	0.330	2.16	86.82	0.86	21.20	1.99	51.53	113.45	n.d.	n.d.
00DKA053f	5.34	2.16	186.49	0.76	0.690	8.78	2970.21	0.63	0.350	2.20	91.97	0.94	19.62	2.24	56.40	93.49	n.d.	n.d.
00DKA053g	5.59	2.59	> 450.00	0.91	0.700	10.98	3706.52	0.84	0.380	2.64	125.63	1.19	22.18	2.36	67.69	114.34	n.d.	n.d.
00DKA053h	5.60	2.50	128.04	0.83	0.730	10.09	3545.37	0.76	0.380	2.31	112.81	1.09	22.56	2.30	63.62	103.72	n.d.	n.d.
00DKA053i	5.22	2.52	120.12	0.86	0.670	9.93	3364.13	0.78	0.340	2.33	108.14	1.10	21.26	2.22	62.41	110.73	n.d.	n.d.
00DKA053j	5.37	2.19	128.59	0.77	0.670	9.07	3082.03	0.66	0.340	2.01	98.42	0.99	21.36	2.23	56.31	106.59	n.d.	n.d.
00DKA053k	5.46	2.28	134.15	0.78	0.660	9.24	3255.44	0.69	0.360	2.41	103.53	1.03	20.86	2.35	59.22	101.00	n.d.	n.d.
00DKA053l	5.33	2.43	127.38	0.81	0.670	9.73	3464.85	0.71	0.340	2.33	108.90	1.47	20.31	2.20	61.34	100.75	n.d.	n.d.
00DKA053m	4.19	1.65	253.77	0.58	0.560	6.58	2334.06	0.48	0.270	2.06	71.60	0.69	18.50	1.66	43.77	88.62	n.d.	n.d.
00DKA053n	4.73	2.13	146.41	0.74	0.630	8.60	2983.02	0.64	0.320	2.07	99.12	0.92	19.56	2.04	57.44	97.97	n.d.	n.d.
00DKA053o	1.46	0.32	359.68	n.d.	0.200	0.62	363.23	n.d.	0.060	0.80	14.00	0.11	4.97	0.38	8.87	8.00	n.d.	n.d.
00DKA053p	4.85	2.08	165.17	0.68	0.610	8.05	2770.75	0.60	0.310	3.26	89.79	0.93	18.04	2.02	53.82	85.77	n.d.	n.d.
00DKA053q	4.88	1.24	209.47	0.61	0.720	6.27	2582.54	0.32	0.320	1.99	51.77	0.67	22.26	1.98	35.19	136.74	n.d.	n.d.
00DKA053r	4.51	1.76	156.18	0.63	0.620	6.81	2554.55	0.51	0.290	2.06	78.69	0.76	18.17	1.84	45.68	107.30	n.d.	n.d.
00DKA053s	4.81	2.08	108.18	0.68	0.630	8.06	2842.57	0.56	0.310	2.28	91.89	0.88	18.11	2.02	52.65	94.83	n.d.	n.d.
00DKA053t	3.80	1.77	228.25	0.58	0.530	6.62	2237.64	0.46	0.260	2.30	72.09	0.77	15.14	1.67	43.92	82.10	n.d.	n.d.
00DKA053u	4.84	1.69	170.76	0.67	0.690	7.29	2448.13	0.48	0.340	2.13	68.73	0.78	20.26	2.15	45.19	137.92	n.d.	n.d.
00DKA053v	4.98	1.96	162.43	0.67	0.680	8.38	2838.34	0.56	0.340	2.25	88.14	0.99	20.61	2.12	52.15	109.08	n.d.	n.d.
00DKA053w	5.48	2.12	140.12	0.78	0.740	9.00	3095.63	0.62	0.360	3.93	95.99	0.92	23.92	2.28	58.92	157.36	n.d.	n.d.
00DKA053x	5.66	2.02	126.58	0.80	0.770	9.36	3182.24	0.59	0.400	2.58	93.27	1.09	23.44	2.57	56.05	149.06	n.d.	n.d.
00DKA053y	5.97	2.14	123.10	0.85	0.800	10.07	3542.24	0.62	0.420	2.85	101.20	1.25	27.61	2.64	56.94	191.74	n.d.	n.d.
00DKA053z	4.80	1.31	159.22	0.56	0.700	6.21	2290.14	0.40	0.320	2.12	57.04	0.70	22.34	2.08	57.01	209.05	n.d.	n.d.
detection limits:	0.03	0.10	2.00	0.30	0.001	0.05	10.00	0.30	0.005	0.01	1.00	0.05	0.20	0.01	5.00	6.00	0.10	0.01

Appendix 7

Chlorine and fluorine geochemical data for bed and composite samples from 2000 (sample information provided in Armstrong 2001a, 2001b)

Appendix 7: Chlorine (Cl) and fluorine (F) geochemical data for 2000 Queenston Formation samples. Sample locations and descriptions are reported by Armstrong (2001a, 2002b). Chlorine and fluorine contents reported in mg/L and detection limits for both elements are 250 mg/L.

Sample #	Cl	F	Sample #	Cl	F	Sample #	Cl	F
00-DKA-104G	<250	975	00-DKA-114D	<250	1050	00-DKA-151E	<250	1050
00-DKA-104H	<250	1075	00-DKA-114E	<250	900	00-DKA-151F	<250	925
00-DKA-104I	<250	1125	00-DKA-114F	<250	975	00-DKA-151G	<250	1075
00-DKA-105A	<250	925	00-DKA-114G	<250	975	00-DKA-151H	<250	1050
00-DKA-105B	<250	475	00-DKA-145A	<250	750	00-DKA-151I	<250	1050
00-DKA-105C	<250	1000	00-DKA-145B	<250	900	00-DKA-151J	<250	1000
00-DKA-106A	<250	1125	00-DKA-145C	<250	675	00-DKA-151K	<250	1050
00-DKA-106B	<250	1050	00-DKA-145D	<250	925	00-DKA-151L	<250	975
00-DKA-106C	<250	850	00-DKA-145E	<250	675	00-DKA-151M	<250	1050
00-DKA-107A	<250	600	00-DKA-145F	<250	925	00-DKA-151N	<250	975
00-DKA-107B	450	<250	00-DKA-145G	<250	750	00-DKA-151O	950	7225
00-DKA-107C	<250	600	00-DKA-145H	675	825	00-DKA-152A	<250	1000
00-DKA-107D	<250	1075	00-DKA-145I	375	850	00-DKA-152B	250	975
00-DKA-107E	<250	475	00-DKA-145J	725	825	00-DKA-152C	<250	925
00-DKA-107F	<250	825	00-DKA-145K	425	700	00-DKA-152D	<250	900
00-DKA-107G	<250	700	00-DKA-148A	<250	975	00-DKA-152E	<250	750
00-DKA-107H	<250	925	00-DKA-148B	<250	900	00-DKA-154A	<250	1075
00-DKA-107I	<250	900	00-DKA-148C	<250	900	00-DKA-154B	<250	1125
00-DKA-107J	250	925	00-DKA-148D	<250	750	00-DKA-154C	<250	1275
00-DKA-107K	<250	825	00-DKA-148E	<250	925	00-DKA-154D	<250	1225
00-DKA-111A	<250	775	00-DKA-148F	<250	925	00-DKA-154E	300	1225
00-DKA-111B	<250	775	00-DKA-148G	<250	700	00-DKA-154F	275	1050
00-DKA-111C	<250	975	00-DKA-148H	<250	900	00-DKA-154G	300	1125
00-DKA-111D	<250	700	00-DKA-148I	250	675	00-DKA-154H	400	1200
00-DKA-113A	<250	925	00-DKA-148J	250	700	00-DKA-154I	500	1200
00-DKA-113B	<250	775	00-DKA-151A	<250	1075	00-DKA-154J	500	1075
00-DKA-114A	<250	900	00-DKA-151B	<250	900	00-DKA-154K	525	1125
00-DKA-114B	250	1000	00-DKA-151C	525	975			
00-DKA-114C	<250	1000	00-DKA-151D	<250	975			

Appendix 8

Ceramic testing results (*from* Armstrong and Frederic 2001)

Table 8-1: Sample list and source information: a) Group 1 samples; b) Group 2 samples.

Table 8-2: Summary of tests conducted.

Table 8-3: Summary of firing and properties testing results for Group 2 samples.

Table 8-4: Sample A1A shrinkage measurements.

Table 8-5: Sample A6A shrinkage measurements.

Table 8-6: Sample B1A shrinkage measurements.

Table 8-7: Sample C2A shrinkage measurements.

Table 8-8: Sample A1A strength test results.

Table 8-9: Sample A6A strength test results.

Table 8-10: Sample B1A strength test results.

Table 8-11: Sample C2A strength test results.

Table 8-12: Sample A1A properties test results.

Table 8-13: Sample A6A properties test results.

Table 8-14: Sample B1A properties test results.

Table 8-15: Sample C2A properties test results.

Table 8-16: Efflorescence results (Group 2 samples).

Table 8-17: Fired colours (Group 2 samples).

Table 8-18: Loss on ignition results (Group 1 and 2 samples).

Figure 8-1: Thermal expansion plot for sample A1A.

Figure 8-2: Thermal expansion plot for sample A1B.

Figure 8-3: Thermal expansion plot for sample A6A.

Figure 8-4: Thermal expansion plot for sample A6B.

Figure 8-5: Thermal expansion plot for sample B1A.

Figure 8-6: Thermal expansion plot for sample B1B.

Figure 8-7: Thermal expansion plot for sample B4A.

Figure 8-8: Thermal expansion plot for sample C2A.

Figure 8-9: Thermal expansion plot for sample C2B.

Figure 8-10: Simultaneous DTA/TGA plots for sample A1A.

Figure 8-11: Simultaneous DTA/TGA plots for sample A1B.

Figure 8-12: Simultaneous DTA/TGA plots for sample A6A.

Figure 8-13: Simultaneous DTA/TGA plots for sample A6B.

Figure 8-14: Simultaneous DTA/TGA plots for sample B1A.

Figure 8-15: Simultaneous DTA/TGA plots for sample B1B.

Figure 8-16: Simultaneous DTA/TGA plots for sample B4A.

Figure 8-17: Simultaneous DTA/TGA plots for sample C2A.

Figure 8-18: Simultaneous DTA/TGA plots for sample C2B.

Table 8-1a: Group 1 samples.

sample #	drill hole #	composed of original samples	top depth (m)	bottom depth (m)	sample interval (m)	lithologic unit #'s
A1B	OGS-00-A1	00DKA145h to 00DKA145k	14.97	24.08	9.11	8 to 13
B1B	OGS-00-B1	00DKA151g to 00DKA151o	18.30	34.43	16.13	8 to 16
B4A	OGS-00-B4	00DKA152a to 00DKA152e	10.59	21.92	11.33	1 to 7
A6B	OGS-00-A6	00DKA148f to 00DKA148j	16.53	26.10	9.57	6 to 11
C2B	OGS-00-C2	00DKA154g to 00DKA154k	13.24	20.33	7.09	5 to 8

Table 8-1b: Group 2 samples.

sample #	drill hole #	composed of original samples	top depth (m)	bottom depth (m)	sample interval (m)	lithologic unit #'s
A1A	OGS-00-A1	00DKA145a to 00DKA145g	4.65	14.97	10.32	1 to 7
A6A	OGS-00-A6	00DKA148b to 00DKA148e	6.55	16.53	9.98	1 to 5
B1A	OGS-00-B1	00DKA151a to 00DKA151f	8.46	18.30	9.84	1 to 7
C2A	OGS-00-C2	00DKA154a to 00DKA154f	0.00	13.24	13.24	1 to 4

Note: for details about drill holes, original samples and lithologic units, see Armstrong (2001a, 2001b).

Table 8-2: Summary of tests conducted ("x" indicates test conducted).

				shrinkage		absorption					Strength (MOR)					
	Sample	TDA	DTA/TGA	dry	fired	cold	boiled	C/B	density	porosity	green	dried	fired	efflores-cence	colour	LOI
Group 2 samples	A1A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	A6A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	B1A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	C2A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Group1 samples	A1B	x	x													x
	A6B	x	x													x
	B1B	x	x													x
	B4A	x	x													x
	C2B	x	x													x

TDA = thermal dilatometric analysis (or thermal expansion)
DTA/TGA = simultaneous "differential thermal analysis/thermal gravimetric analysis"
C/B = cold absorption/boiled absorption (calculated)
MOR = modulus of rupture
LOI = loss on ignition

Table 8-3: Summary of firing and properties testing results for Group 2 samples.

	Shrinkage			Absorption					Strength (MOR)					
Sample	dry shrinkage (%)	fired shrinkage (%)	total shrinkage (%)	cold (%)	boiled (%)	C/B	density (g/cc)	porosity (%)	green MOR (psi)	dried MOR (psi)	fired MOR (psi)	efflores-cence	fired colour	LOI (%)
A1A	0.73	0.35	1.12	17.57	20.58	0.85	1.76	36.16	125.3	186.8	786.8	yes	tan with white discoloration	15.82
A6A	1.67	0.46	2.15	19.75	21.28	0.93	1.75	37.28	124.0	142.7	733.0	yes	light pinkish tan with white discoloration	12.92
B1A	2.90	1.03	3.89	13.91	16.85	0.83	1.80	30.37	141.9	188.7	1257.4	yes	medium pinkish tan	14.08
C2A	3.12	0.92	4.13	15.38	18.08	0.85	1.72	31.05	164.4	219.6	1283.9	yes	light pinkish tan	13.16

C/B = cold absorption/boiled absorption (calculated)
MOR = modulus of rupture
psi = pounds per square inch
some = some sub-samples effloresced and some did not.
LOI = loss on ignition

Table 8-4: Sample A1A shrinkage measurements.

		Green		Dried			Fired			Total
	Sub-Sample ID	Weight (g)	Length (mm)	Weight (g)	Length (mm)	% Shrinkage	Weight (g)	Length (mm)	% Shrinkage	% Shrinkage
Samples for Fired Strength	1	218.9	100.0	202.2	99.2	0.80	166.7	99.1	0.10	0.90
	2	227.4	100.0	210.5	99.3	0.70	173.2	98.8	0.50	1.20
	3	220.7	100.0	203.9	99.0	1.00	168.1	98.7	0.30	1.30
	4	189.8	100.0	173.8	99.3	0.70	145.0	98.9	0.40	1.10
	5	209.1	100.0	192.0	99.1	0.90	158.7	98.9	0.20	1.10
Samples for Dried Strength	6	210.6	100.0	194.1	99.4	0.60				
	7	194.3	100.0	177.9	99.5	0.50				
	8	191.6	100.0	173.7	99.5	0.50				
	9	218.7	100.0	201.4	99.3	0.70				
	10	202.9	100.0	186.3	99.1	0.90				
Samples for Green Strength	11	n/a	n/a							
	12	n/a	n/a							
	13	181.8	100.0							
	14	214.6	100.0							
	15	199.7	100.0							
					Average =	0.73	162.34	98.9	0.35	1.12

Extruded in lab extruder at 22.5% moisture content.
Dried in lab oven @ 110°C.
Fired in lab kiln @ 1950°F.

Table 8-5: Sample A6A shrinkage measurements.

		Green		Dried			Fired			Total
	Sub-Sample ID	Weight (g)	Length (mm)	Weight (g)	Length (mm)	% Shrinkage	Weight (g)	Length (mm)	% Shrinkage	% Shrinkage
Samples for Fired Strength	1	217.8	100.0	189.8	98.3	1.70	161.2	97.9	0.41	2.11
	2	204.3	100.0	177.3	98.5	1.50	151.6	98.0	0.51	2.01
	3	220.9	100.0	192.4	98.2	1.80	164.2	97.9	0.31	2.11
	4	201.0	100.0	173.1	98.1	1.90	149.4	97.7	0.41	2.31
	5	214.3	100.0	186.3	98.4	1.60	159.4	97.8	0.61	2.21
Samples for Dried Strength	6	232.3	100.0	204.5	98.1	1.90				
	7	229.6	100.0	200.9	98.5	1.50				
	8	240.2	100.0	211.0	98.5	1.50				
	9	205.1	100.0	177.8	98.3	1.70				
	10	215.3	100.0	187.9	98.4	1.60				
Samples for Green Strength	11	206.6	100.0							
	12	224.9	100.0							
	13	213.8	100.0							
	14	234.5	100.0							
	15	199.7	100.0							
					Average =	1.67	157.16	97.9	0.46	2.15

Extruded in lab extruder at 24% moisture content.
Dried in lab oven @ 110°C.
Fired in lab kiln @ 1950°F.

Table 8-6: Sample B1A shrinkage measurements.

		Green		Dried			Fired			Total
	Sub-Sample ID	Weight (g)	Length (mm)	Weight (g)	Length (mm)	% Shrinkage	Weight (g)	Length (mm)	% Shrinkage	% Shrinkage
Samples for Fired Strength	1	214.6	100.0	188.6	97.1	2.90	159.6	96.2	0.93	3.83
	2	217.5	100.0	191.9	97.0	3.00	161.9	95.9	1.13	4.13
	3	200.9	100.0	172.2	97.2	2.80	149.7	96.2	1.03	3.83
	4	192.1	100.0	167.3	97.0	3.00	143.1	96.0	1.03	4.03
	5	189.0	100.0	163.2	97.3	2.70	140.9	96.4	0.92	3.62
Samples for Dried Strength	6	196.5	100.0	170.0	97.1	2.90				
	7	210.5	100.0	185.1	97.1	2.90				
	8	211.6	100.0	185.6	97.0	3.00				
	9	190.7	100.0	164.7	97.1	2.90				
	10	188.2	100.0	162.2	97.1	2.90				
Samples for Green Strength	11	197.8	100.0							
	12	194.1	100.0							
	13	205.5	100.0							
	14	205.7	100.0							
	15	172.2	100.0							
					Average =	2.90	151.03	96.1	1.03	3.89

Extruded in lab extruder at 20% moisture content.
Dried in lab oven @ 110°C.
Fired in lab kiln @ 1950°F.

Table 8-7: Sample C2A shrinkage measurements.

		Green		Dried			Fired			Total
	Sub-Sample ID	Weight (g)	Length (mm)	Weight (g)	Length (mm)	% Shrinkage	Weight (g)	Length (mm)	% Shrinkage	% Shrinkage
Samples for Fired Strength	1	203.7	100.0	172.5	97.0	3.00	144.2	95.8	1.24	4.24
	2	200.8	100.0	169.4	96.8	3.20	142.1	95.6	1.24	4.44
	3	188.7	100.0	158.1	96.9	3.10	133.5	96.0	0.93	4.03
	4	191.9	100.0	160.6	96.8	3.25	136.3	95.6	1.19	4.44
	5	188.9	100.0	157.9	96.8	3.20	133.6	96.5	0.31	3.51
Samples for Dried Strength	6	194.7	100.0	163.5	96.8	3.20				
	7	208.3	100.0	177.8	96.7	3.35				
	8	199.7	100.0	168.2	97.0	3.05				
	9	208.6	100.0	176.4	97.0	3.00				
	10	212.0	100.0	180.8	97.2	2.85				
Samples for Green Strength	11	219.2	100.0							
	12	212.1	100.0							
	13	216.3	100.0							
	14	209.9	100.0							
	15	206.1	100.0							
					Average =	3.12	137.92	95.9	0.92	4.13

Extruded in lab extruder at 23% moisture content.
Dried in lab oven @ 110°C.
Fired in lab kiln @ 1950°F.

Table 8-8: Sample A1A strength test results.

Green Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
11	1.00	1.00	23.7	124.4
12	1.00	1.00	23.1	121.3
13	1.00	1.00	24.8	130.2
14	1.00	1.00	23.5	123.4
15	1.00	1.00	24.2	127.1
		Average =	23.9	125.3

Dried Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
6	1.00	1.00	35.5	186.4
7	1.00	1.00	36.1	189.5
8	1.00	1.00	35.4	185.9
9	1.00	1.00	35.0	183.8
10	1.00	1.00	35.9	188.5
		Average =	35.6	186.8

Fired Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
1	1.00	1.00	148.4	779.1
2	1.00	1.00	150.7	791.2
3	1.00	1.00	150.2	788.6
4	1.00	1.00	147.5	774.4
5	1.00	1.00	152.5	800.6
		Average =	149.9	786.8

in. = inches
psi = pounds per square inch
MOR = modulus of rupture

Table 8-9: Sample A6A strength test results.

Green Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
11	1.00	1.00	25.0	131.3
12	1.00	1.00	22.7	119.2
13	1.00	1.00	23.1	121.3
14	1.00	1.00	24.4	128.1
15	1.00	1.00	22.9	120.2
		Average =	23.6	124.0

Dried Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
6	1.00	1.00	27.6	144.9
7	1.00	1.00	28.1	147.5
8	1.00	1.00	26.4	138.6
9	1.00	1.00	26.6	139.7
10	1.00	1.00	27.2	142.8
		Average =	27.2	142.7

Fired Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
1	1.00	1.00	135.3	710.3
2	1.00	1.00	144.1	756.5
3	1.00	1.00	142.0	745.5
4	1.00	1.00	137.8	723.5
5	1.00	1.00	138.9	729.2
		Average =	139.6	733.0

in. = inches
psi = pounds per square inch
MOR = modulus of rupture

Table 8-10: Sample B1A strength test results.

Green Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
11	1.00	1.00	26.8	140.7
12	1.00	1.00	27.1	142.3
13	1.00	1.00	26.5	139.1
14	1.00	1.00	27.7	145.4
15	1.00	1.00	27.0	141.8
		Average =	27.0	141.9

Dried Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
6	1.00	1.00	35.8	188.0
7	1.00	1.00	34.9	183.2
8	1.00	1.00	38.1	200.0
9	1.00	1.00	36.2	190.1
10	1.00	1.00	34.7	182.2
		Average =	35.9	188.7

Fired Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
1	1.00	1.00	237.4	1246.4
2	1.00	1.00	244.2	1282.1
3	1.00	1.00	241.9	1270.0
4	1.00	1.00	230.5	1210.1
5	1.00	1.00	243.5	1278.4
		Average =	239.5	1257.4

in. = inches
psi = pounds per square inch
MOR = modulus of rupture

Table 8-11: Sample C2A strength test results.

Green Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
11	1.00	1.00	30.5	160.1
12	1.00	1.00	32.4	170.1
13	1.00	1.00	30.0	157.5
14	1.00	1.00	31.2	163.8
15	1.00	1.00	32.5	170.6
		Average =	31.3	164.4

Dried Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
6	1.00	1.00	42.1	221.0
7	1.00	1.00	42.8	224.7
8	1.00	1.00	40.1	210.5
9	1.00	1.00	43.6	228.9
10	1.00	1.00	40.5	212.6
		Average =	41.8	219.6

Fired Strength				
Sample ID	Breadth (in.)	Depth (in.)	Peak Load	MOR (psi)
1	1.00	1.00	244.3	1282.6
2	1.00	1.00	242.9	1275.2
3	1.00	1.00	248.3	1303.6
4	1.00	1.00	245.7	1289.9
5	1.00	1.00	241.6	1268.4
		Average =	244.6	1283.9

in. = inches
psi = pounds per square inch
MOR = modulus of rupture

Table 8-12: Sample A1A properties test results.

Sample ID	Fired Wt. (g)	Cold Wt. (g)	Boil Wt. (g)	Sus.Wt. (g)	Cold Abs. %	Boiled Abs. %	C/B	Density (g/cc)	Porosity %
1	166.7	196.3	201.3	105.4	17.76	20.76	0.86	1.74	36.08
2	173.2	204.0	209.5	111.1	17.80	20.97	0.85	1.76	36.91
3	168.1	197.6	202.6	105.8	17.55	20.52	0.86	1.74	35.63
4	145.0	170.2	174.4	93.2	17.38	20.28	0.86	1.79	36.21
5	158.7	186.2	191.0	101.2	17.34	20.37	0.85	1.77	36.00
				Average =	17.57	20.58	0.85	1.76	36.16

Table 8-13: Sample A6A properties test results.

Sample ID	Fired Wt. (g)	Cold Wt. (g)	Boil Wt. (g)	Sus.Wt. (g)	Cold Abs. %	Boiled Abs. %	C/B	Density (g/cc)	Porosity %
1	161.2	192.9	195.9	103.0	19.67	21.53	0.91	1.73	37.36
2	151.6	181.9	183.8	97.9	20.04	21.26	0.94	1.76	37.52
3	164.2	196.6	199.2	106.8	19.74	21.29	0.93	1.78	37.85
4	149.4	178.8	180.8	95.3	19.64	21.02	0.93	1.75	36.71
5	159.4	190.8	193.3	101.6	19.67	21.28	0.92	1.74	36.95
				Average =	19.75	21.28	0.93	1.75	37.28

Table 8-14: Sample B1A properties test results.

Sample ID	Fired Wt. (g)	Cold Wt. (g)	Boil Wt. (g)	Sus.Wt. (g)	Cold Abs. %	Boiled Abs. %	C/B	Density (g/cc)	Porosity %
1	159.6	183.1	188.1	99.5	14.66	17.85	0.82	1.80	32.13
2	161.9	184.5	189.0	99.2	14.00	16.77	0.83	1.80	30.22
3	149.7	170.0	174.4	90.5	13.55	16.55	0.82	1.78	29.51
4	143.1	162.9	167.2	87.4	13.81	16.82	0.82	1.79	30.18
5	140.9	159.9	163.8	86.8	13.50	16.29	0.83	1.83	29.78
				Average =	13.91	16.85	0.83	1.80	30.37

Table 8-15: Sample C2A properties test results.

Sample ID	Fired Wt. (g)	Cold Wt. (g)	Boil Wt. (g)	Sus.Wt. (g)	Cold Abs. %	Boiled Abs. %	C/B	Density (g/cc)	Porosity %
1	144.2	167.0	171.1	88.1	15.74	18.59	0.85	1.74	32.31
2	142.1	165.0	168.6	86.4	16.14	18.68	0.86	1.73	32.27
3	133.5	153.4	158.7	78.7	14.96	18.92	0.79	1.67	31.57
4	136.3	156.5	159.1	80.0	14.81	16.73	0.89	1.72	28.82
5	133.6	153.9	156.9	79.8	15.25	17.50	0.87	1.73	30.30
				Average =	15.38	18.08	0.85	1.72	31.05

Wt. = weight
Sus. = Suspended
Abs. = absorption
C/B = cold absorption / bioled absorption
g = grams
cc = cubic centimetre

Table 8-16: Efflorescence results (Group 2 samples)	
Sample ID	**Efflorescence**
A1A - 6	Effloresced
A1A - 7	Effloresced
A1A - 8	Effloresced
A1A - 9	Effloresced
A1A - 10	Effloresced
A6A - 6	Not Effloresced
A6A - 7	Effloresced
A6A - 8	Effloresced
A6A - 9	Not Effloresced
A6A - 10	Effloresced
B1A - 6	Not Effloresced
B1A - 7	Effloresced
B1A - 8	Not Effloresced
B1A - 9	Effloresced
B1A - 10	Not Effloresced
C2A - 6	Effloresced
C2A - 7	Effloresced
C2A - 8	Not Effloresced
C2A - 9	Effloresced
C2A - 10	Not Effloresced

Table 8-17: Fired colours (Group 2 samples).	
Sample ID	**Fired Colour**
A1A	Tan with white discoloration
A6A	Light pinkish tan with white discoloration
B1A	Medium pinkish tan
C2A	light pinkish tan

Table 8-18: Loss on ignition (LOI) results (Group 1 and 2 samples).									
Sample ID	**A1A**	**A1B**	**A6A**	**A6B**	**B1A**	**B1B**	**B4A**	**C2A**	**C2B**
crucible	17.9091	19.2027	18.5064	21.3486	20.8133	20.975	20.6645	19.8789	20.8448
crucible + dry	59.615	59.3428	57.4599	59.1959	56.8246	50.4853	53.8314	59.3286	55.9231
crucible + fired	53.0191	53.6624	52.4267	53.6269	51.7555	46.2466	49.7036	54.1385	50.3105
dry weight	41.7059	40.1401	38.9535	37.8473	36.0113	29.5103	33.1669	39.4497	35.0783
fired weight	35 11	34.4597	33.9203	32.2783	30.9422	25.2716	29.0391	34.2596	29.4657
LOI	0.1582	0.1415	0.1292	0.1471	0.1408	0.1436	0.1245	0.1316	0.1600
LOI %	**15.82**	**14.15**	**12.92**	**14.71**	**14.08**	**14.36**	**12.45**	**13.16**	**16.00**

Figure 8-1: thermal expansion plot for sample A1A (arrows indicate heating and cooling cycle direction).

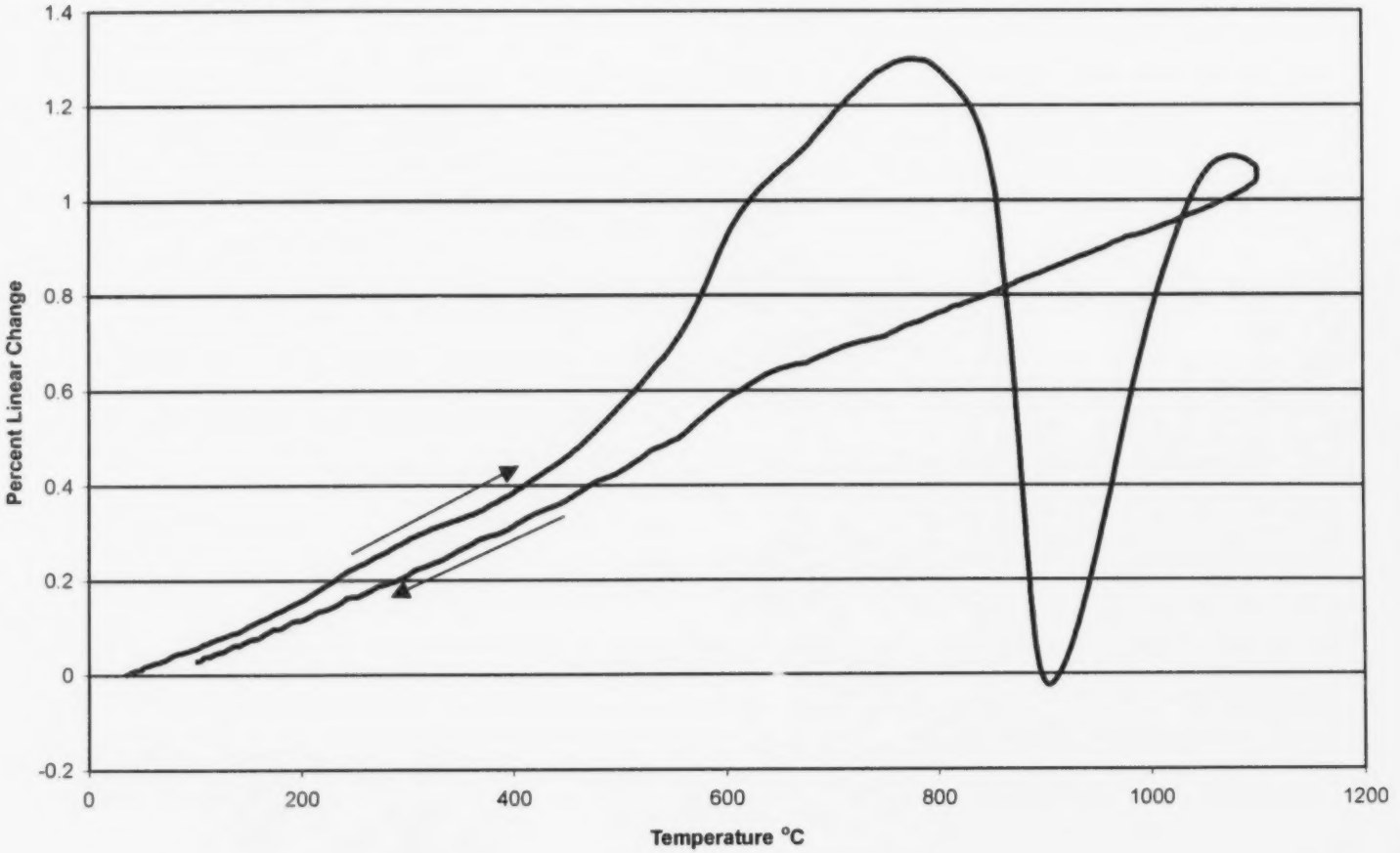


Figure 8-2: thermal expansion plot for sample A1B (arrows indicate heating and cooling direction).

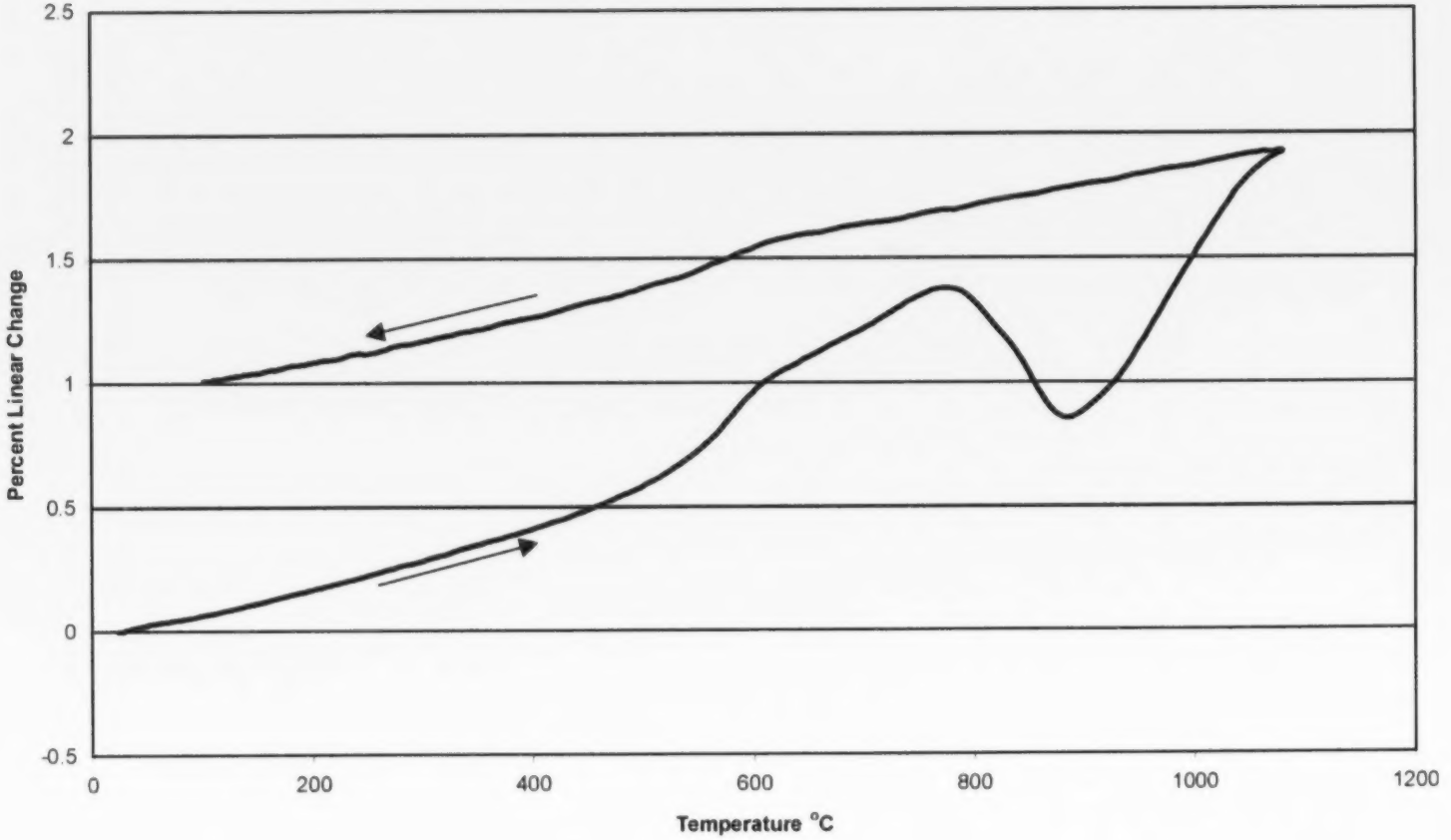


Figure 8-3: thermal expansion plot for sample A6A (arrows indicate heating and cooling direction).

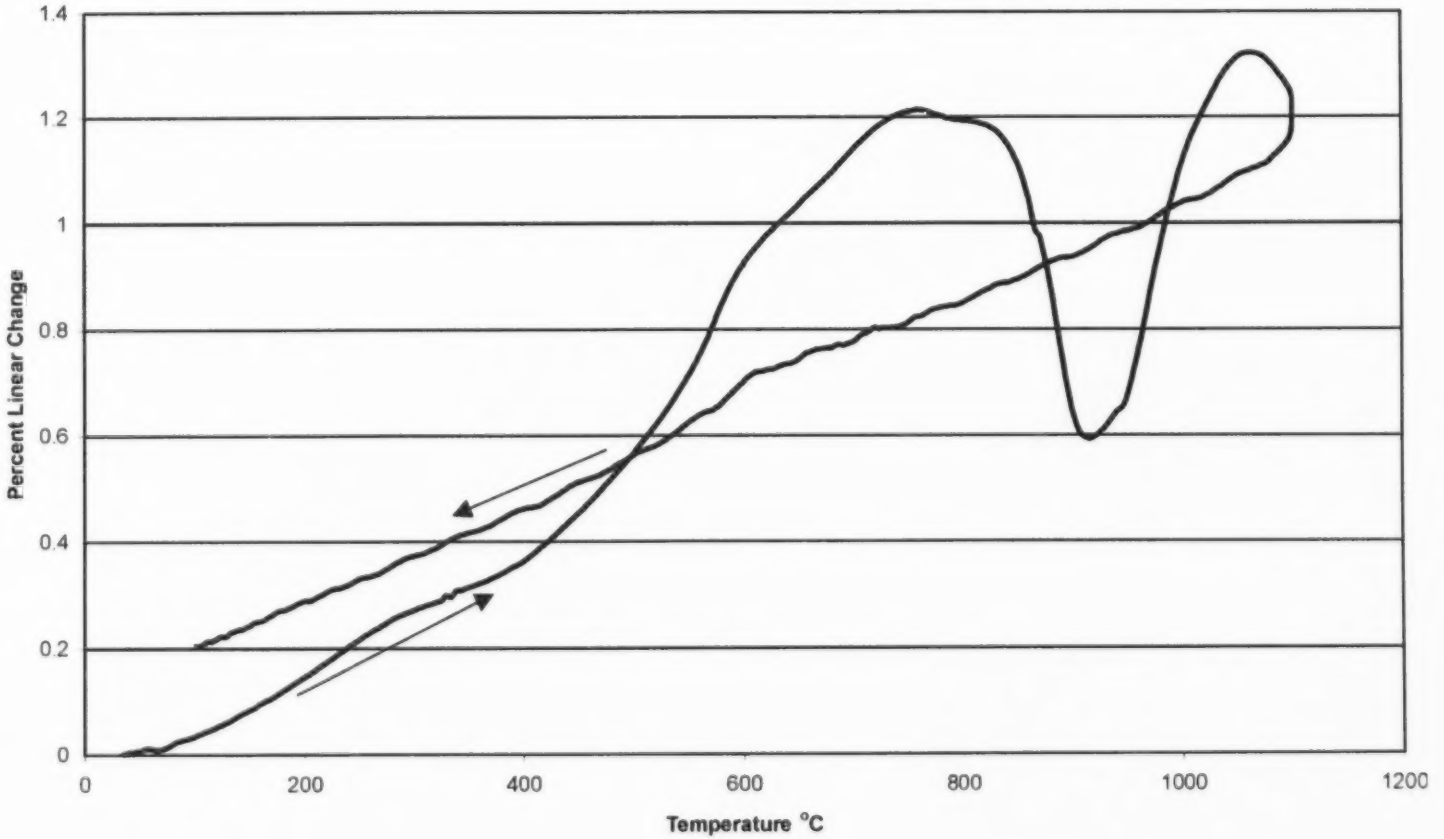


Figure 8-4: thermal expansion plot for sample A6B (arrows indicate heating and cooling direction).

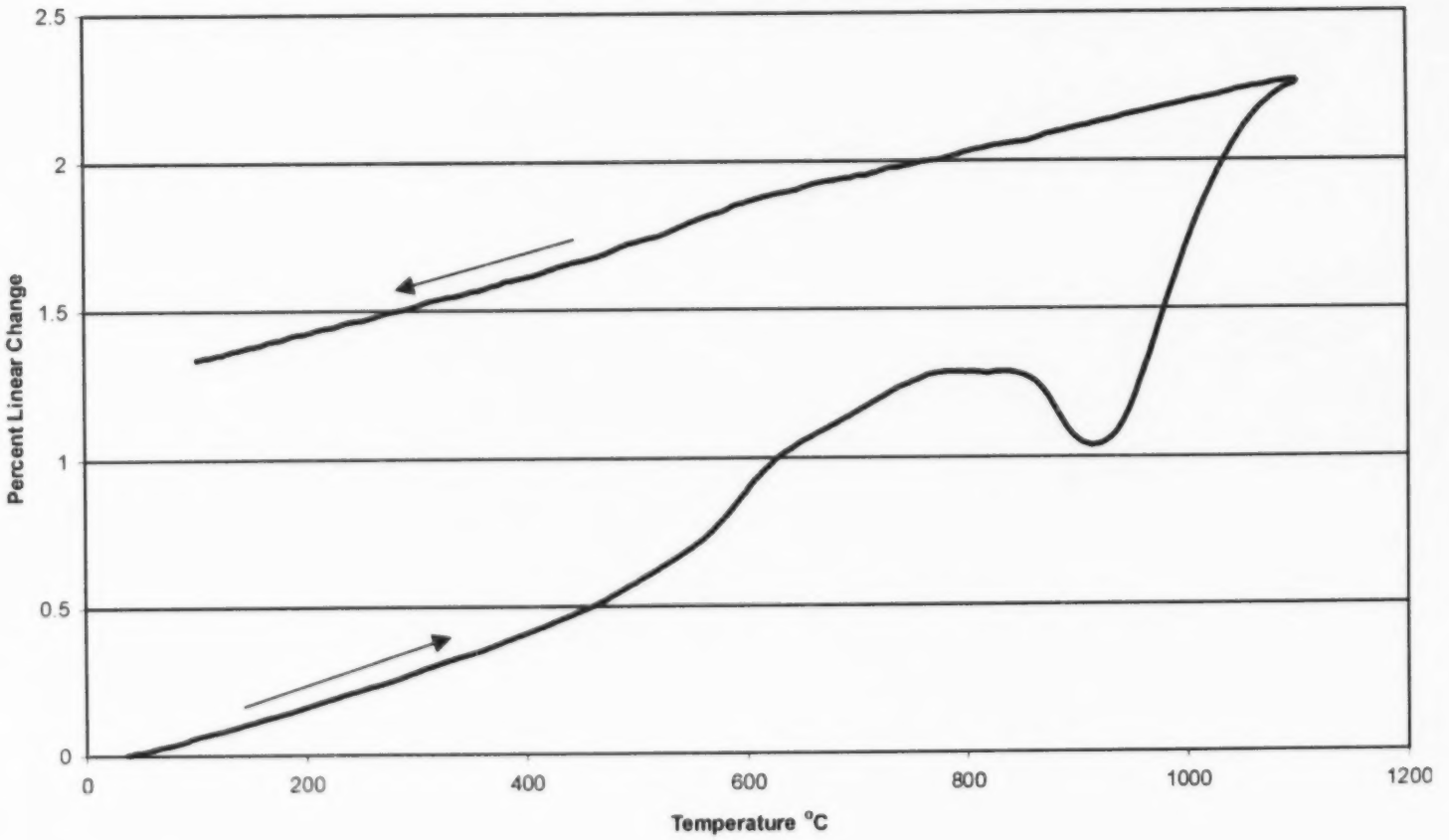


Figure 8-5: thermal expansion plot for sample B1A (arrows indicate heating and cooling cycle direction).

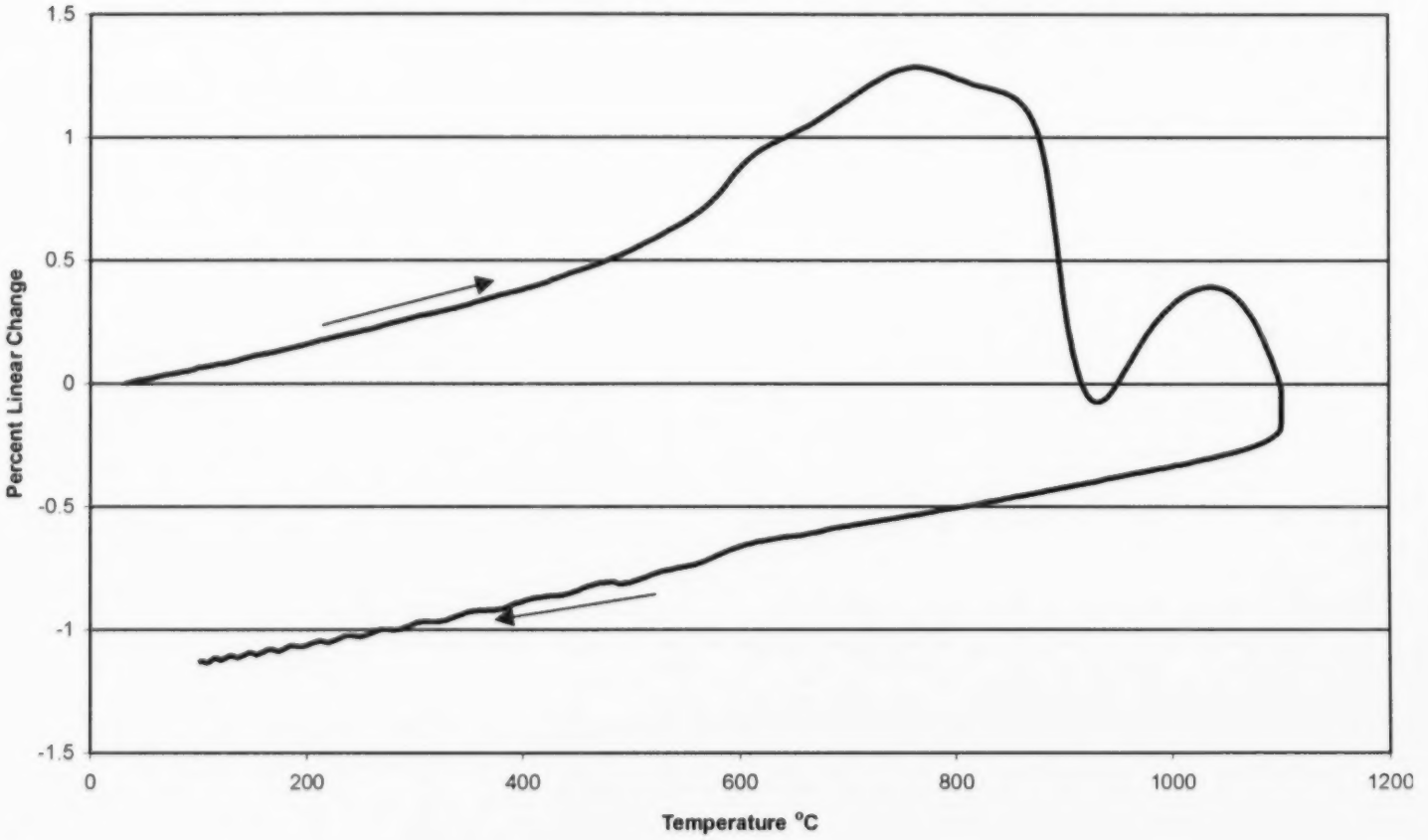


Figure 8-6: thermal expansion plot for sample B1B (arrows indicate heating and cooling cycle direction).

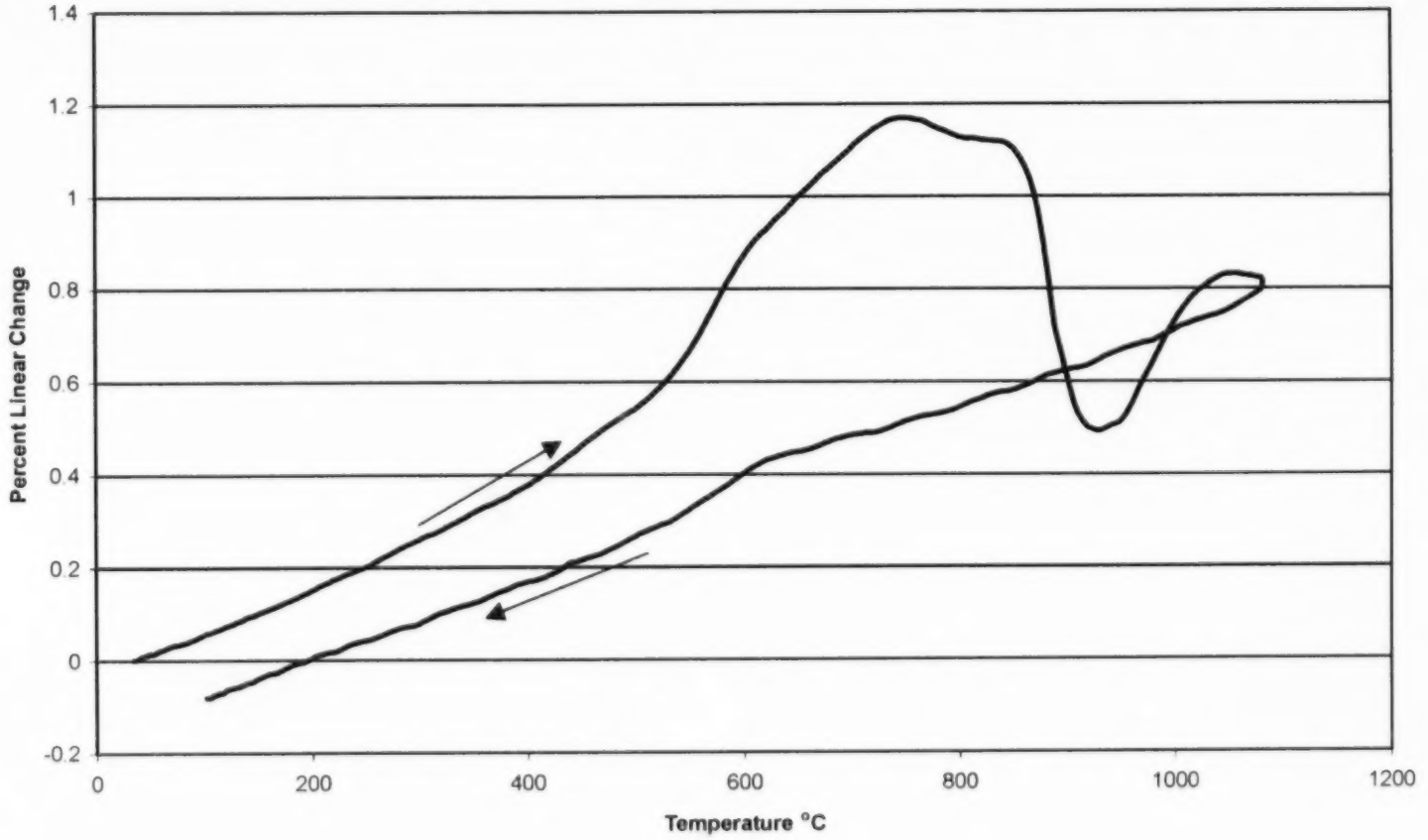
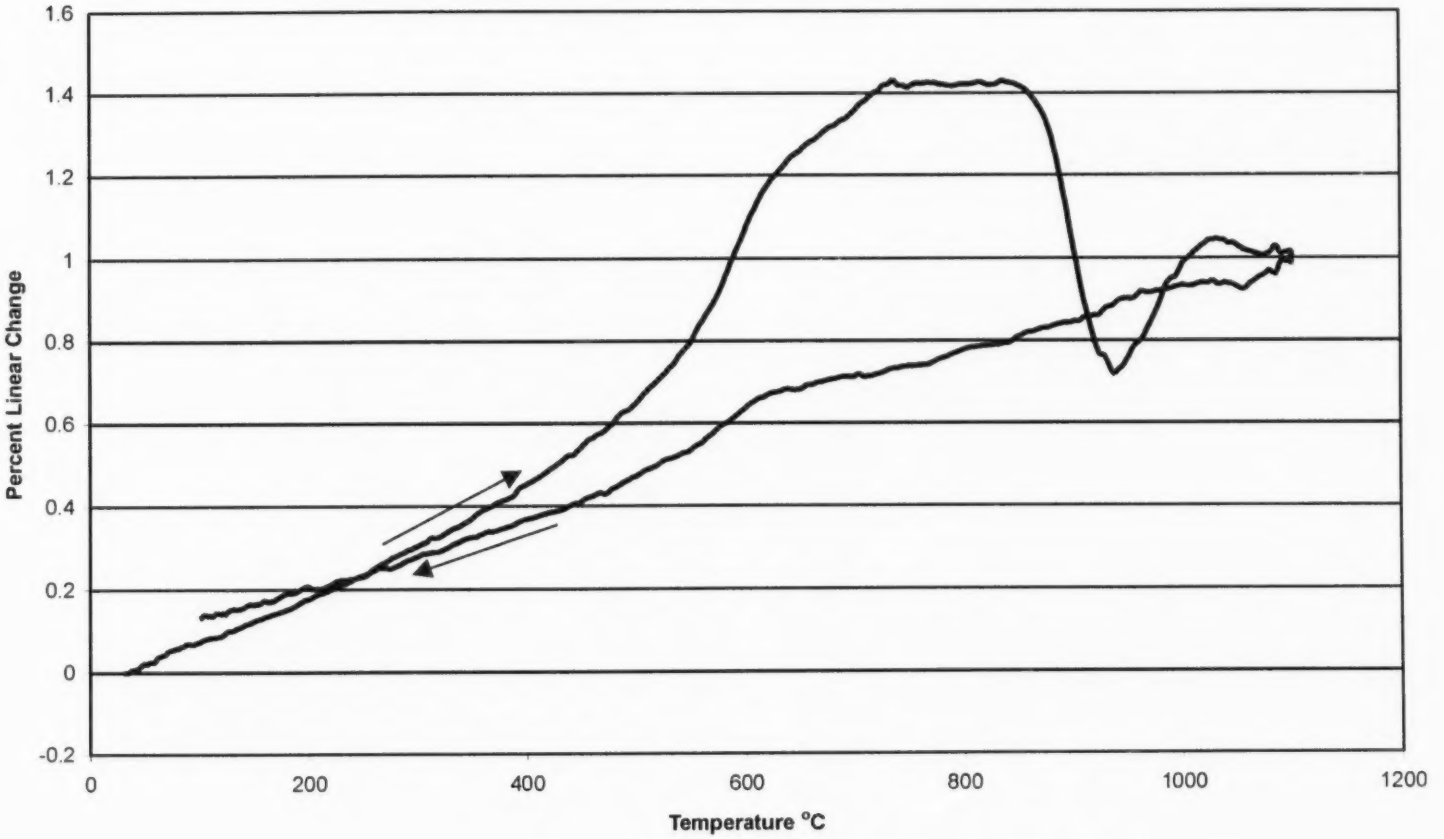


Figure 8-7: thermal expansion plot for sample B4A (arrows indicate heating and cooling cycle direction).



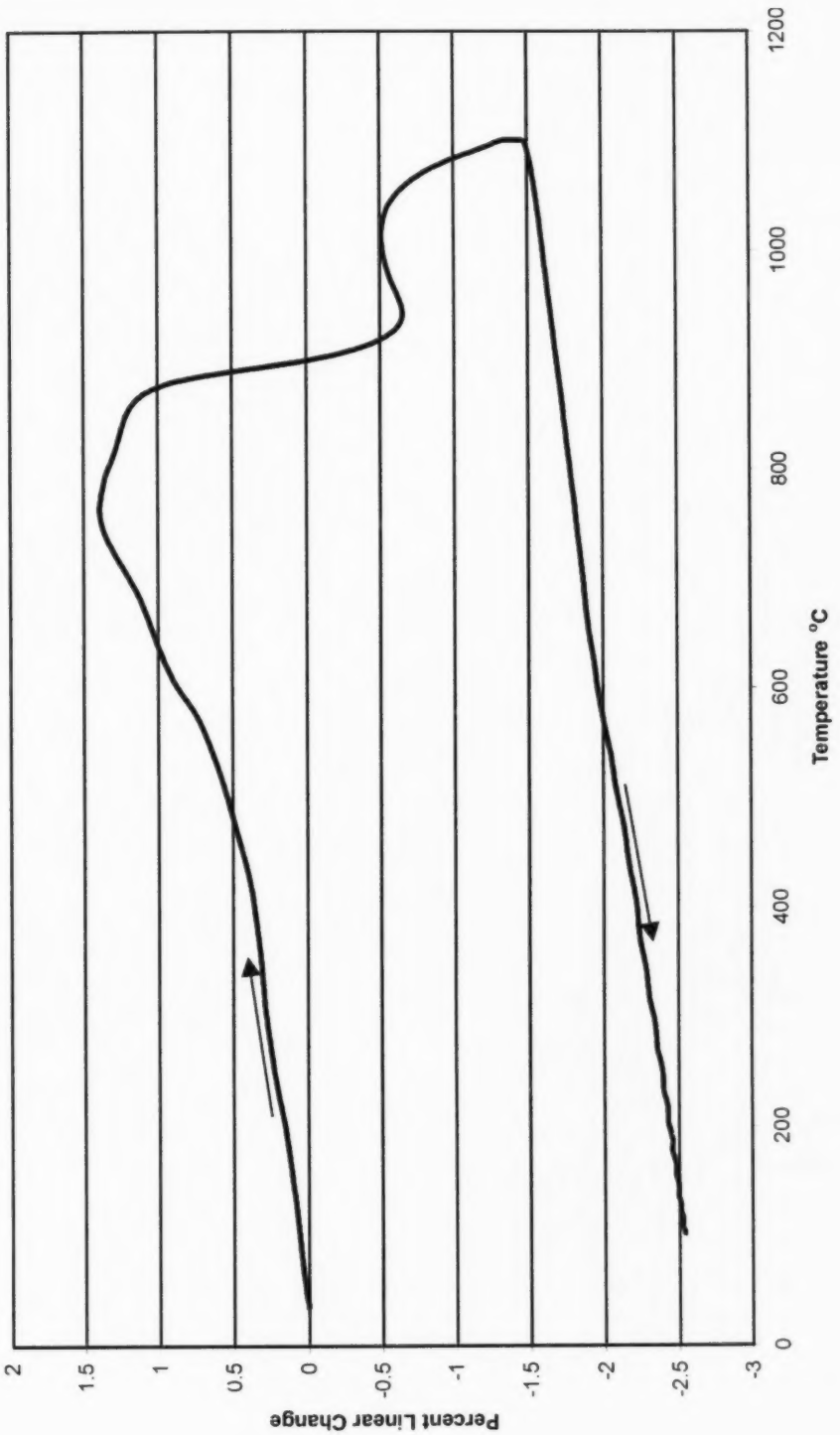
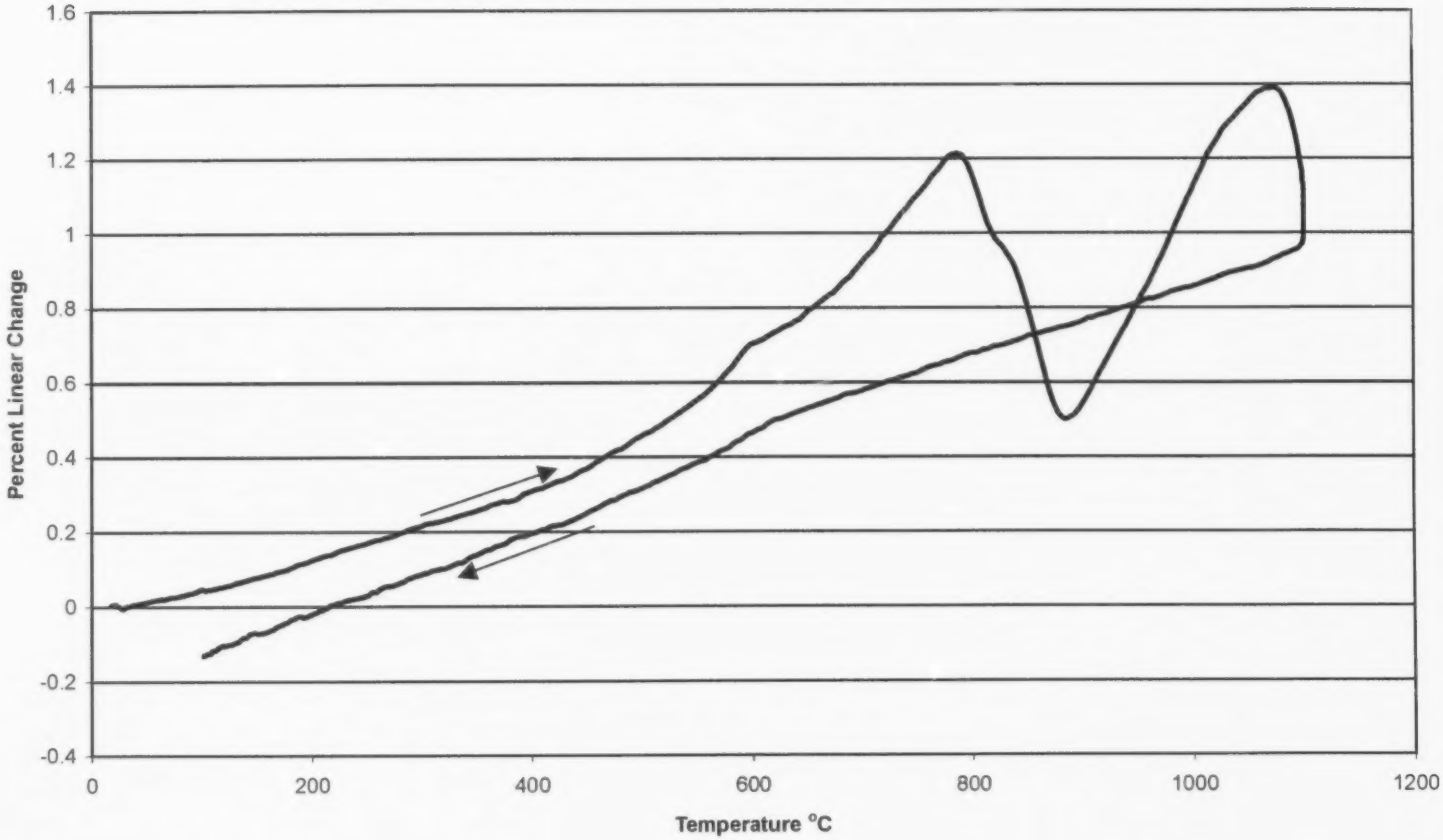


Figure 8-8: thermal expansion plot for sample C2A (arrows indicate heating and cooling direction).

Figure 8-9: thermal expansion plot for sample C2B (arrows indicate heating and cooling direction).



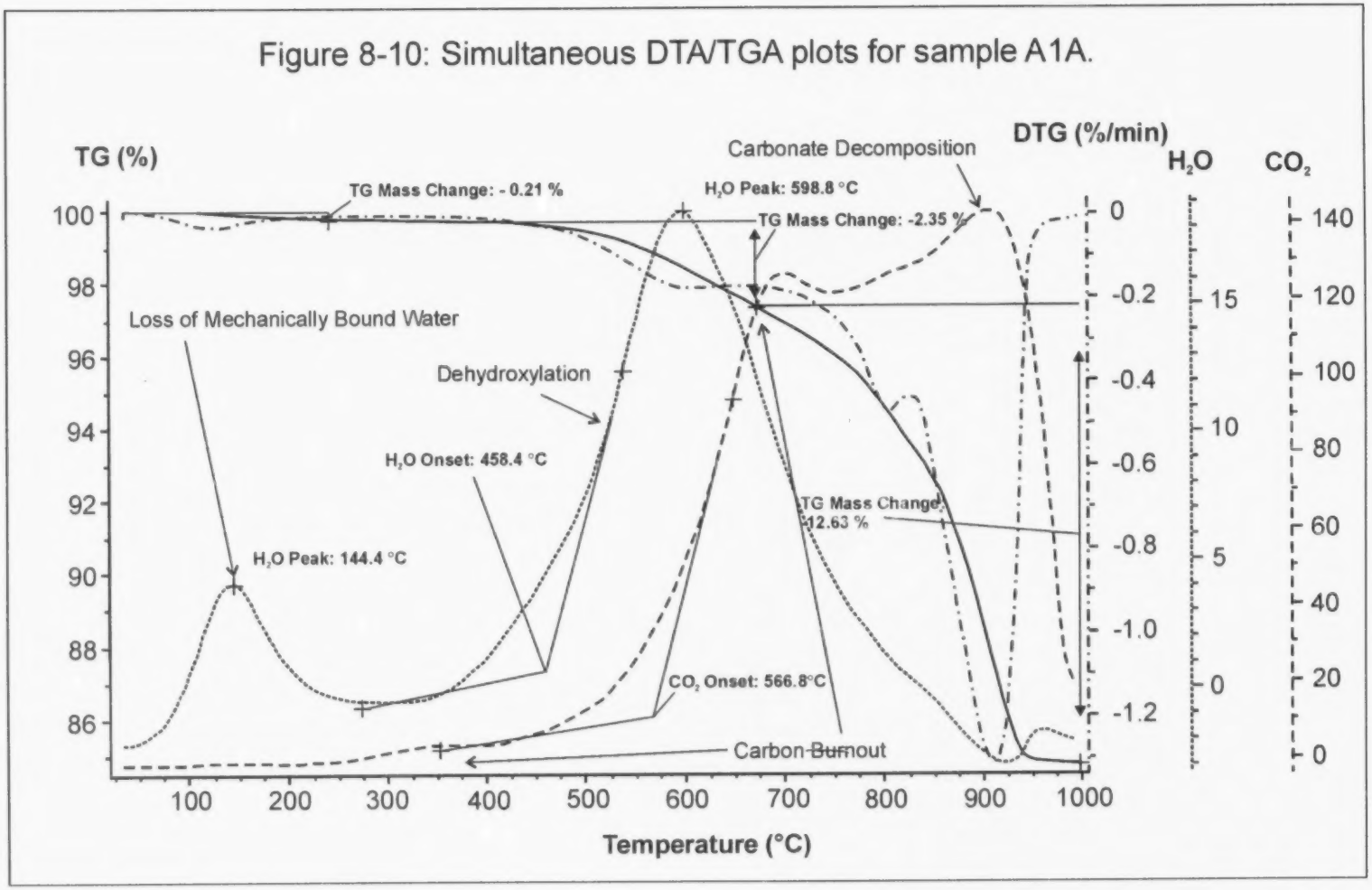


Figure 8-10: Simultaneous DTA/TGA plots for sample A1A.

Figure 8-11: Simultaneous DTA/TGA plots for sample A1B.

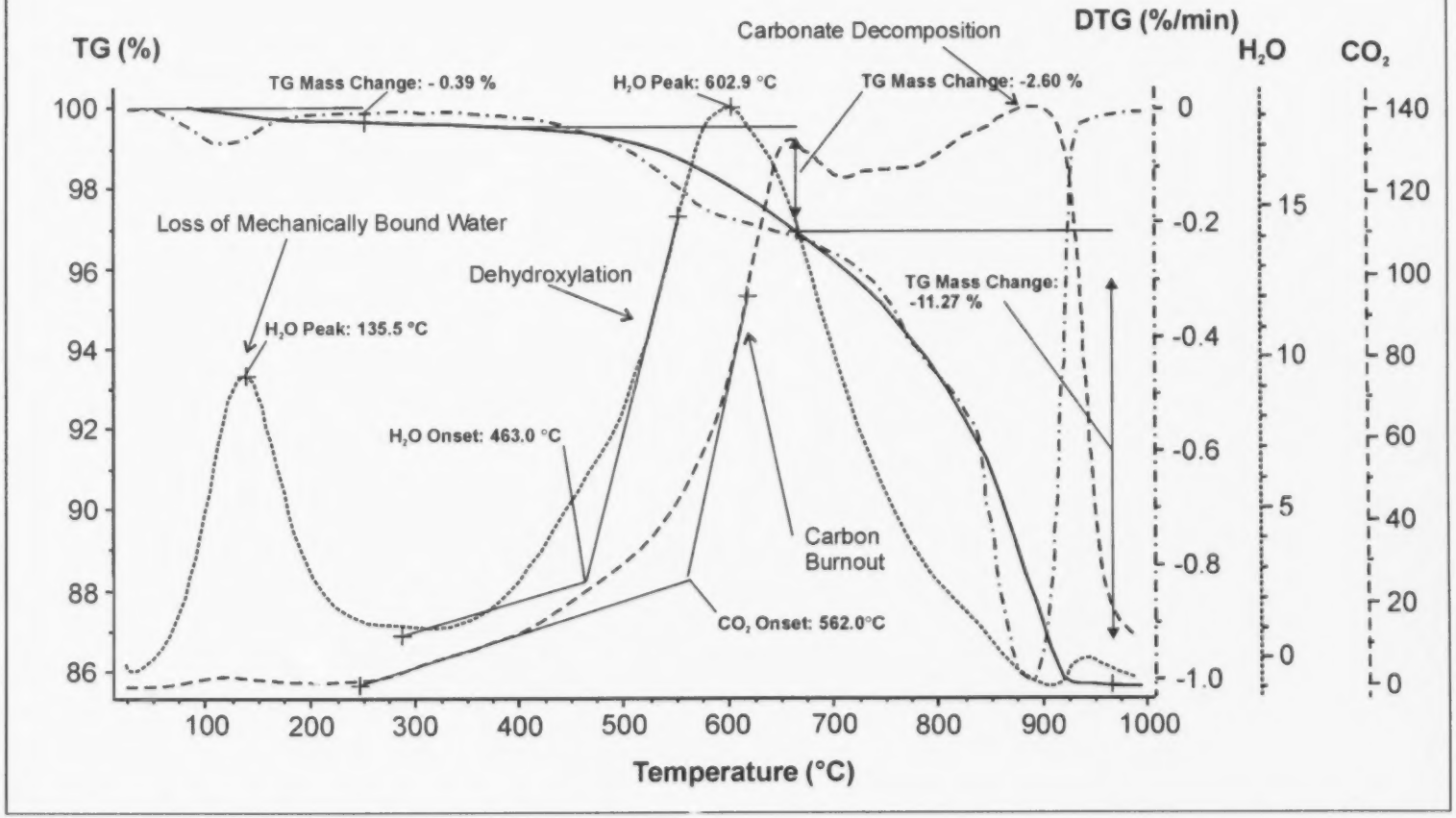
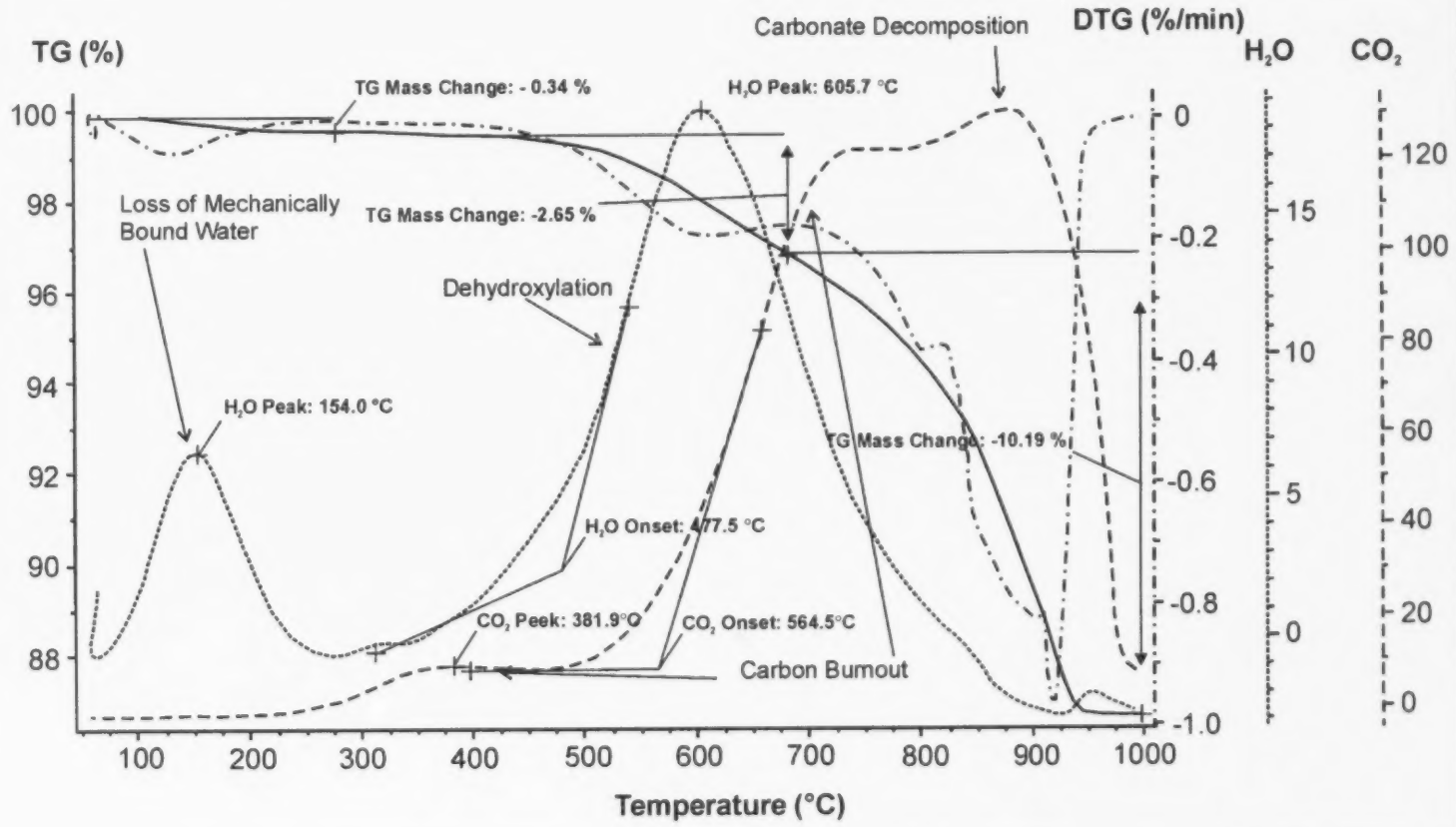


Figure 8-12: Simultaneous DTA/TGA plots for sample A6A.



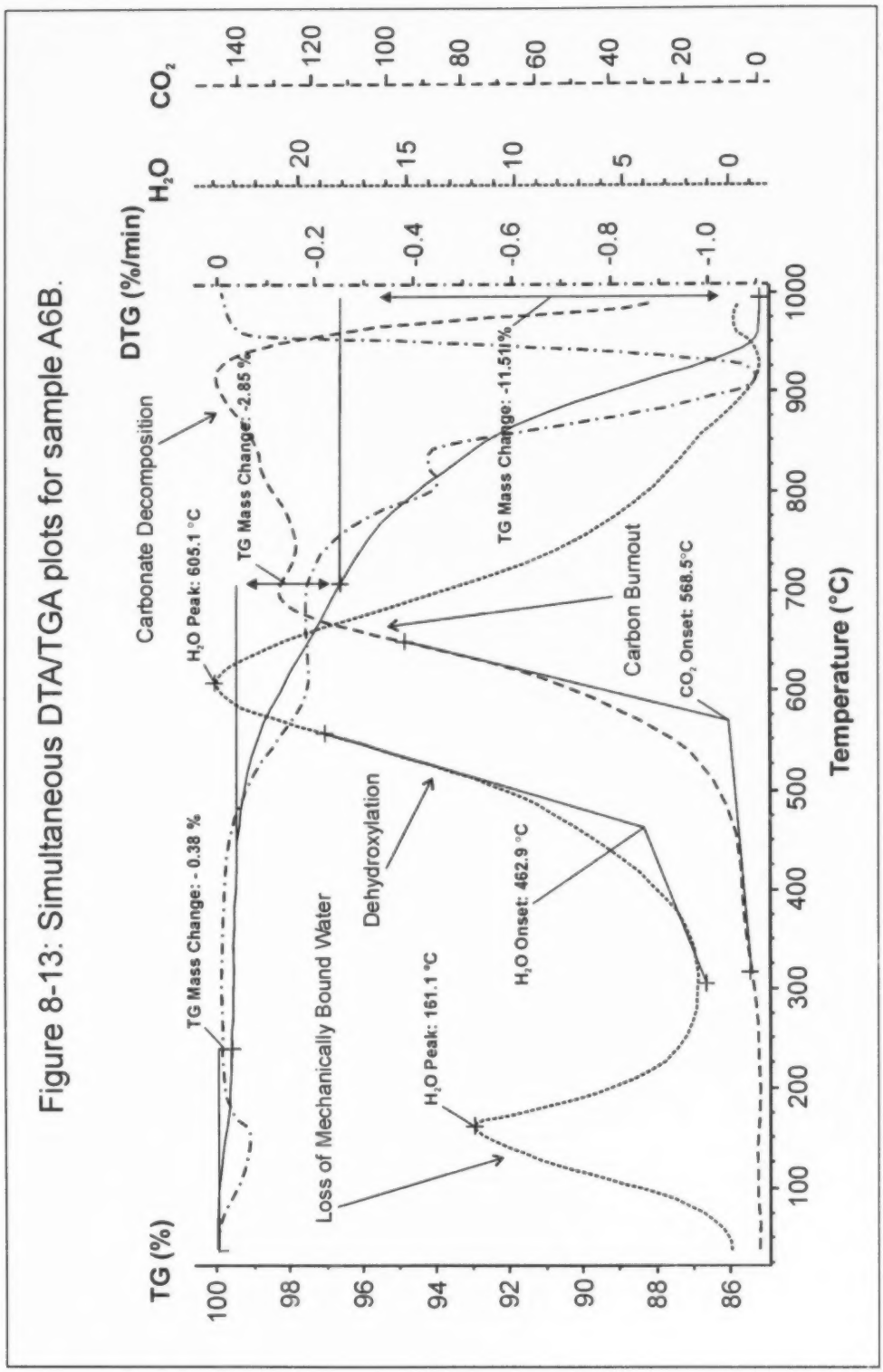


Figure 8-13: Simultaneous DTA/TGA plots for sample A6B.

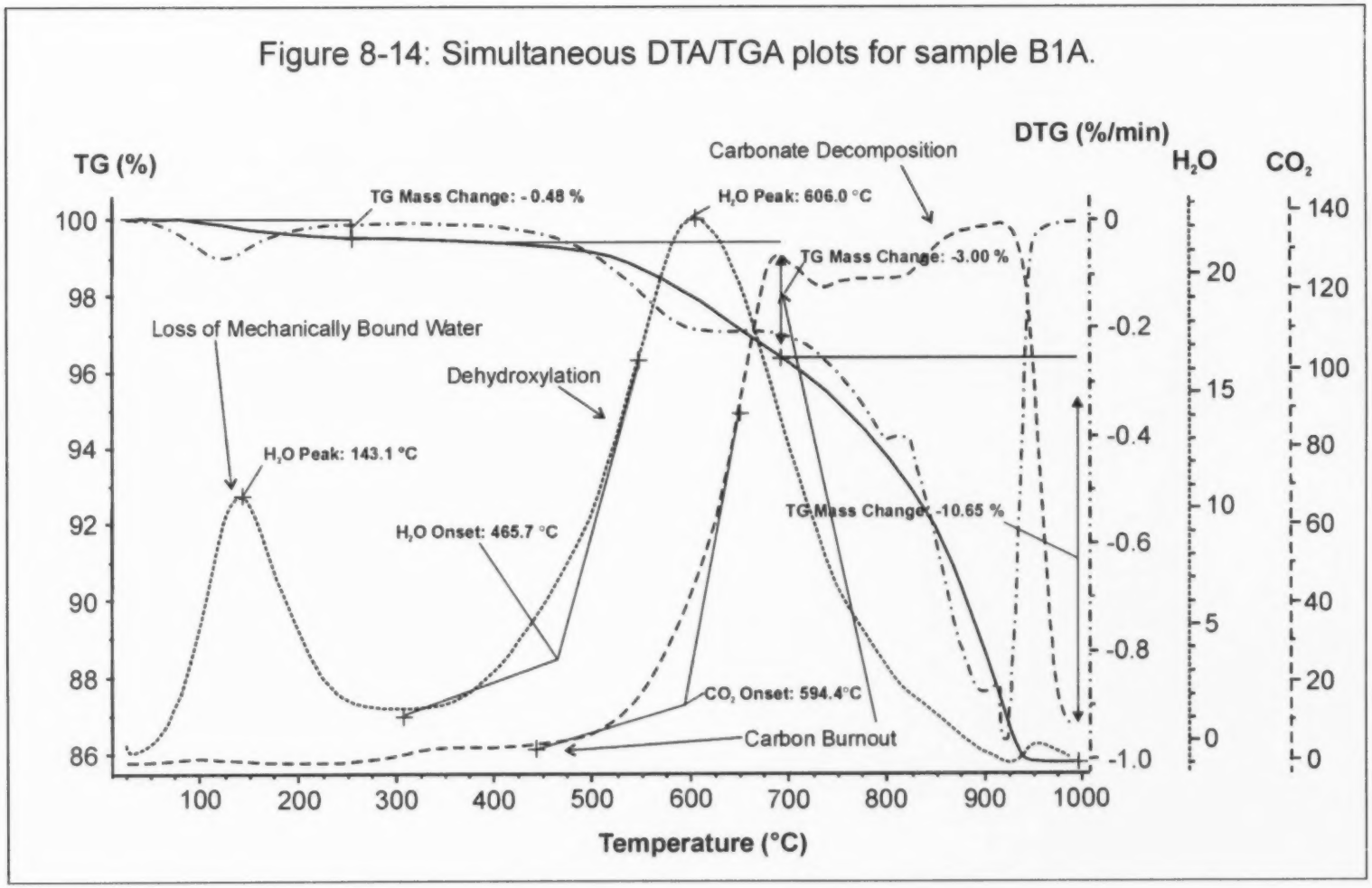
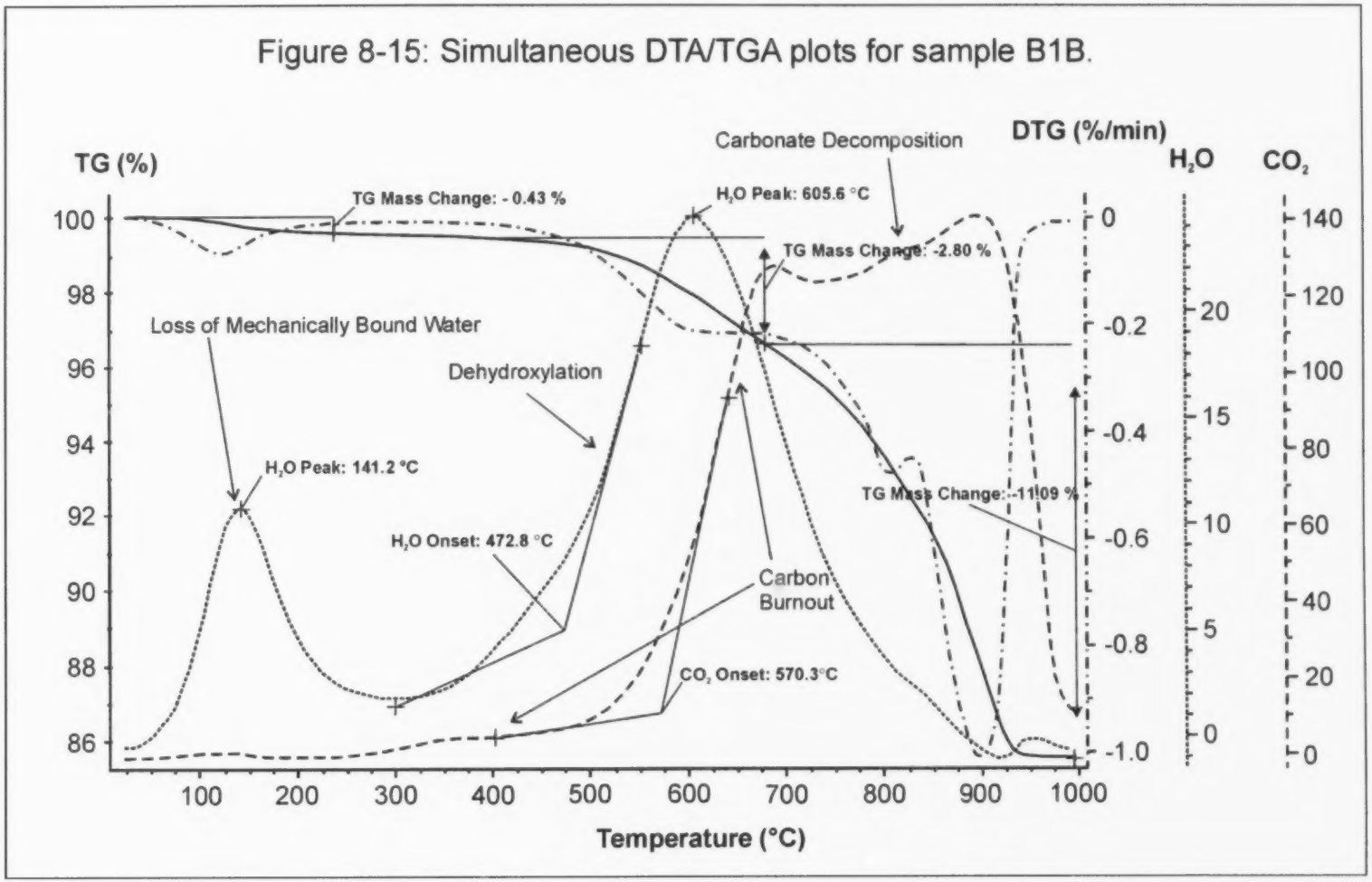


Figure 8-14: Simultaneous DTA/TGA plots for sample B1A.

Figure 8-15: Simultaneous DTA/TGA plots for sample B1B.



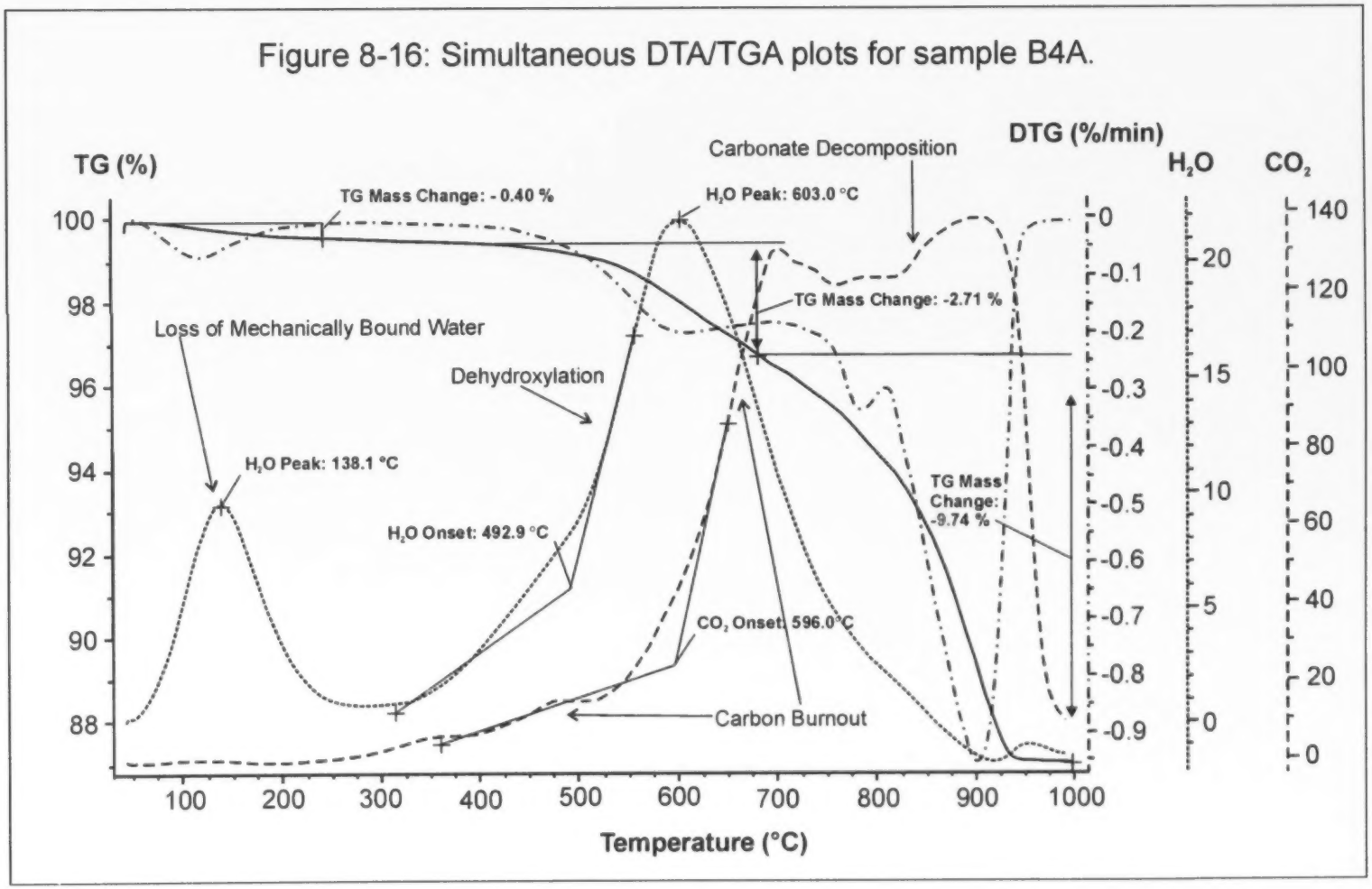


Figure 8-16: Simultaneous DTA/TGA plots for sample B4A.

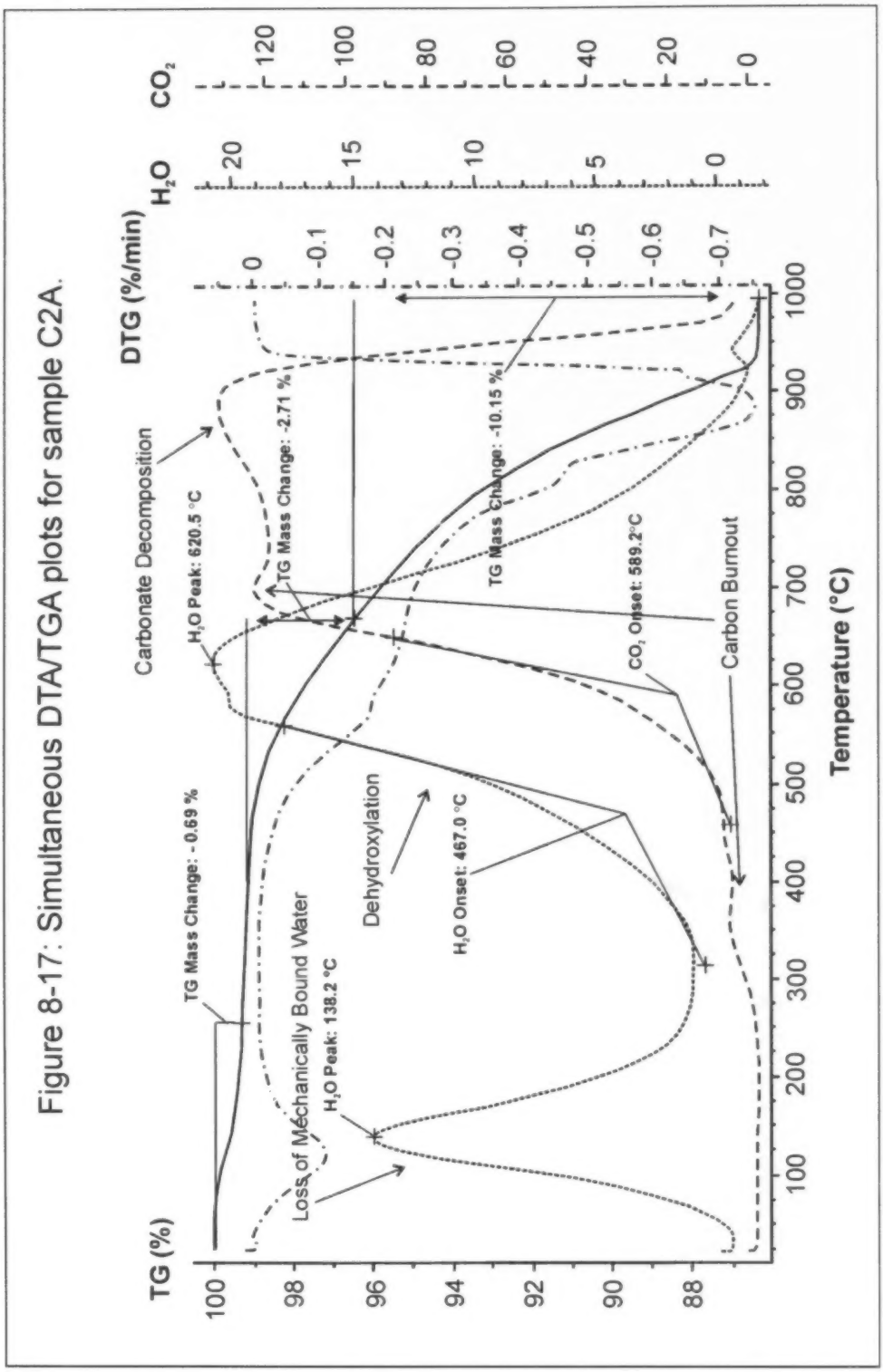
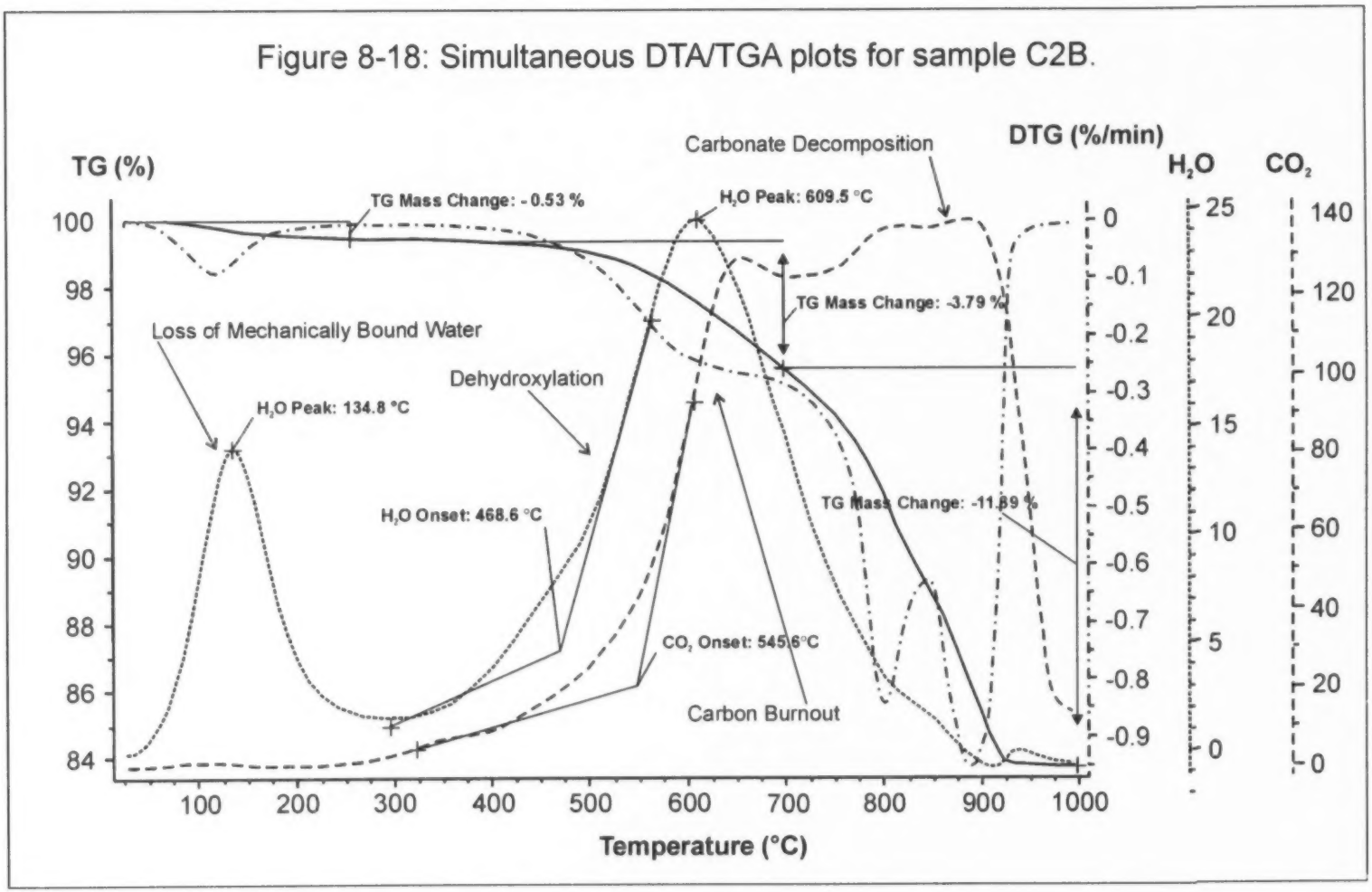


Figure 8-17: Simultaneous DTA/TGA plots for sample C2A.

Figure 8-18: Simultaneous DTA/TGA plots for sample C2B.



Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.